INDUSTRIAL ASSESSMENT FOR TRACKED COMBAT VEHICLES

OCTOBER 1995

PREFACE AND ACKNOWLEDGMENTS

Victory in the Cold War era has brought significant changes to the defense industry. Since the peak year in 1985, total defense procurement has declined by 67 percent in real terms. Defense suppliers have responded to these cuts in predictable ways. Factories have been restructured, reduced, or closed. Skilled personnel have been laid off. Some firms have merged or restructured; others have abandoned defense production entirely. Because these changes could have important consequences for the Department's ability to meet its future mission requirements, we are analyzing the effects of these changes in selected industrial sectors. This report describes the results of one of those studies -- the Department's assessment of the tracked combat vehicle industry.

This study was prepared under the direction of Mr. John Goodman, Deputy Assistant Secretary of Defense for Industrial Affairs. It was led by Major General John Longhouser, U.S. Army Program Executive Officer for Armored Systems Modernization, and Mr. Martin Meth, Director, Industrial Capabilities and Assessments, Office of the Secretary of Defense. Representatives from the Army and Marine Corps and the Office of the Secretary of Defense actively participated throughout the conduct of the study. The Department especially would like to acknowledge the contributions of Mr. Robert Read and Mr. Tom Zemke who served as the assessment focal points; Major General Oscar Decker (U.S.A., Retired), Mr. Mike Mukherjee, Mr. Dave Warlick, Ms. Terri Wyckoff, and Mr. Prince Young, who served as primary technical advisors; and Mr. Gary Powell who served as assessment coordinator. This report would not have been possible without the support of Mr. Gilbert Decker, Assistant Secretary of the Army (Research, Development, and Acquisition), Dr. Ken Oscar, Deputy Assistant Secretary of the Army (Procurement), and Mr. Keith Charles, Deputy Assistant Secretary of the Army (Plans, Programs, and Policy), and the knowledge, professionalism, and hard work of Mr. Richard Bayard, COL Tom Britt, Mr. Jerry Chapin, Mr. Steve Linke, Ms. Nanette Ramsey, Mr. Andrus Viilu, and Mr. Walter Zeitfuss.

We welcome comments on this report. Please address them to Mr. John Goodman, Deputy Assistant Secretary of Defense (Industrial Affairs), 3300 Defense Pentagon, Washington, DC 20301-3300.

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EXECUTIVE SUMMARY

DoD tracked combat vehicle (TCV) procurement has declined significantly from the peak years of the mid-1980s. As procurements have declined, the TCV industry has consolidated from three prime contractors to two -- General Dynamics Land Systems and United Defense, Limited Partnership. Both prime contractors supplying TCVs for DoD use are profitable, and both are taking steps to reduce costs and improve their competitive position. DoD TCV funding is expected to remain relatively stable for the foreseeable future. Funding stability can be as critical as absolute funding dollars. Current and planned new vehicle, derivative, and upgrade/modification programs,[1] coupled with prospective foreign sales of medium/light vehicles, generally will be sufficient to sustain needed prime contractor and supplier industrial (engineering and manufacturing) capabilities. Planned advanced technology demonstrators and funded research and development programs will also sustain a level of TCV engineering capabilities that will be just adequate to support TCV technology needs.

Tracked Combat Vehicles

TCVs are ground combat systems. More mobile than wheeled vehicles, they can cross natural and man-made obstacles and urban terrain, in all weather conditions, while under fire.

The Army and Marines use TCVs for four basic missions, all designed to win on the battlefield as quickly as possible.

[1] This assessment of TCV industrial capabilities is based primarily on spending plans established in the February 1995 Future Years Defense Plan, which covers 1996 through 2001. DoD spending for years after 2001 was considered only for those programs with well-defined plans. All years are fiscal years unless stated otherwise.

- Close combat. Tanks, fighting vehicle systems, armored personnel carriers, and command and control vehicles provide offensive fire power, transport troops, and integrate combat battlefield activities.
- Fire support. Self-propelled artillery and multiple launch rocket systems provide lethal, indirect firepower.
- Combat support. Armored bridge launchers and armored engineer vehicles provide operational assistance by crossing barriers and clearing or laying obstacles.
- Amphibious assault. Amphibious assault vehicles attack from the sea and continue the attack on land.

TCVs fall into two weight classes -- heavy and medium/light.[2] Heavy TCVs weigh over 40 tons and normally are fabricated from steel. Medium/light TCVs weigh less than 40 tons and normally are fabricated from aluminum. In the future, TCVs are expected to make greater use of composite materials.

Industrial Capabilities

TCVs must meet stringent and highly specialized military operational requirements. TCV design, integration, and most key manufacturing capabilities are not available from commercial, or other defense, industries. However, the industrial capabilities required to produce TCVs are generally similar enough for the two weight classes that a manufacturer of one class could also manufacture the other class. Both prime contractors are developing the industrial capabilities to design, integrate, and fabricate both heavy and medium/light TCVs.

[2] Originally, there were three tracked combat vehicle classes--heavy, medium, and light. Over the years, increased operational requirements led to heavier armor, larger guns, and more complex fire control systems. The result has been increased weight, effectively reducing the number of classes to two.

Design

The engineering capabilities most important to the design, fabrication, and support of TCVs are shown in Table ES-1. Prime contractors are the only source of vehicle engineering and integration expertise for TCV system design and fabrication.

TABLE ES-1
IMPORTANT TCV ENGINEERING CAPABILITIES

CAPABILITIES	PRIME CONTRACTOR	TCV SUPPLIERS	DEPOTS
Systems engineering[1]	X	X	
Vehicle systems integration[2]	X		
Electrical	X	X	
Mechanical	X	X	
Welding	X	X	
CAD/CAM design	X	X	
Metallurgists	X	X	X
Machine tool programmers	X	X	X
Machine & weld toolmakers	X	X	X
Electronics & optics	X	X	
Vehicle test	X		X

1. Systems engineering capabilities include the prime contractor's software and design engineering expertise for vehicle systems and supplier provided subsystems.
2. Vehicle systems integration capabilities include the prime contractor's design integration and manufacturing integration skills.

Though some of these capabilities are used in other defense applications, or are available from commercial suppliers (Table ES-2), others (specifically those associated with armor structures, large mobile guns, and sophisticated powertrains and suspensions) are available only from TCV manufacturers.

TABLE ES-2 TCV ENGINEERING SKILLS & EXPERIENCE LEVEL COMPARISON			
COMPONENT	TCV DEFENSE	OTHER DEFENSE	COMMERCIAL
Armor structure	X		
Armaments	X		
Command & control	X	X	X
Communication	X	X	X
Design integration	X	X	
Fire control	X	X	
NBC* protection	X	X	
Powertrain	X		
Suspension	X		
Survivability	X	X	

*NBC -- Nuclear, biological, and chemical.

Manufacturing

Prime contractors, suppliers, and government facilities provide manufacturing capabilities to build, modify, and overhaul TCVs. Prime contractors perform systems integration, structural fabrication, end item assembly, and final tests. Though manufacturing processes are different for steel and aluminum, the differences do not preclude either prime contractor from bidding on any TCV contract or operating established government-owned TCV production facilities. Suppliers manufacture components and subsystems. The Department generally uses its own depot facilities to repair, overhaul, and modify fielded systems. In a few specific cases, depots act as suppliers to prime contractors.[3]

World Market

World production data for heavy TCVs are available only for tanks. Forecast International (a private market research and forecasting firm) projects worldwide production of

[3] The Anniston, Letterkenny, and Red River Army depots provide (or will provide) refurbished TCV components to the prime contractors for integration into the Abrams, Bradley, and Paladin vehicle upgrade programs. The Watervliet and Rock Island Arsenals manufacture new or modified components such as cannons, gun mounts, and recoil mechanisms for the Abrams and M109s and provide them to the prime contractors as government furnished equipment.

new tanks will increase from approximately $4.9 billion in 1995 to $6.6 billion in 1999 -- a 35 percent increase. Russia, Ukraine, China, India, Pakistan, and other Asian nations are expected to account for over 70 percent of that production, mostly for internal consumption. Western nations appear to be focusing on major upgrades of existing tanks over that same period. U.S. producer prospects to compete for this business appear limited.

Forecast International projects the worldwide production of medium/light TCVs will increase from about $1.5 billion in 1995 to $2.7 billion in 1998 (a 78 percent increase), before declining to $1.7 billion in 2003. Worldwide, the number of medium/light tracked vehicle manufacturers has increased significantly over the last ten years, from 12 in 1985 to 36 today. Producers from the Russian Federation, China, the Republic of Korea, Turkey, and Pakistan are all striving to enter the export market. The potential world export market for medium/light TCVs is larger than that for heavy vehicles. U.S. manufacturers are positioned to compete in this market.

DoD Requirements

DoD requirements for TCVs can be categorized into three key areas: (1) procurement -- buying new TCVs, TCV derivatives, or upgrades to fielded TCVs; (2) research and development -- developing and integrating technologies and applications for future weapon systems; and (3) sustainment -- providing parts and engineering support to maintain field readiness.

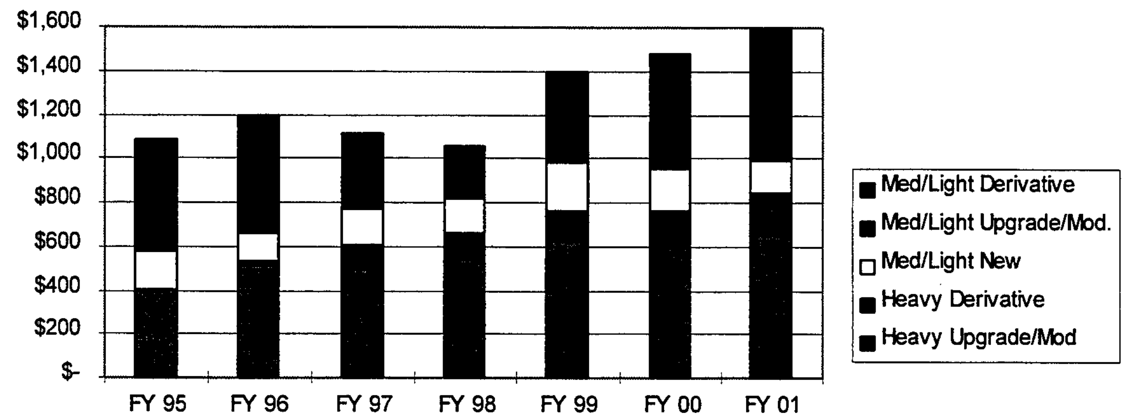
Procurement

Figure ES-1 summarizes the Department's TCV production requirements[4] for heavy and medium/light vehicles. These are substantially smaller than during the peak production years of

[4] Production requirements include new, derivative, and major upgrade programs. New programs reflect complete production articles based on new designs and new components. Derivative programs reflect production articles that are based, in part, on existing designs or are comprised of components from existing systems. Major upgrade programs are existing systems being substantially modified.

the mid-1980s. For example, no new tanks are expected to be produced for the U.S. Army in the next ten years. Nevertheless, DoD procurement funding will increase from about $1.1 billion in 1995 to about $1.6 billion in 2001 -- for a total of $9.2 billion, evenly split between vehicle classes. About 75 percent of the total will be spent on upgrade programs.

Figure ES-1: TCV Procurement Funding By New, Derivative or Upgrade (1995 Constant $M)



Source: 1996-97 President's Budget, dated February 1995

Research and Development

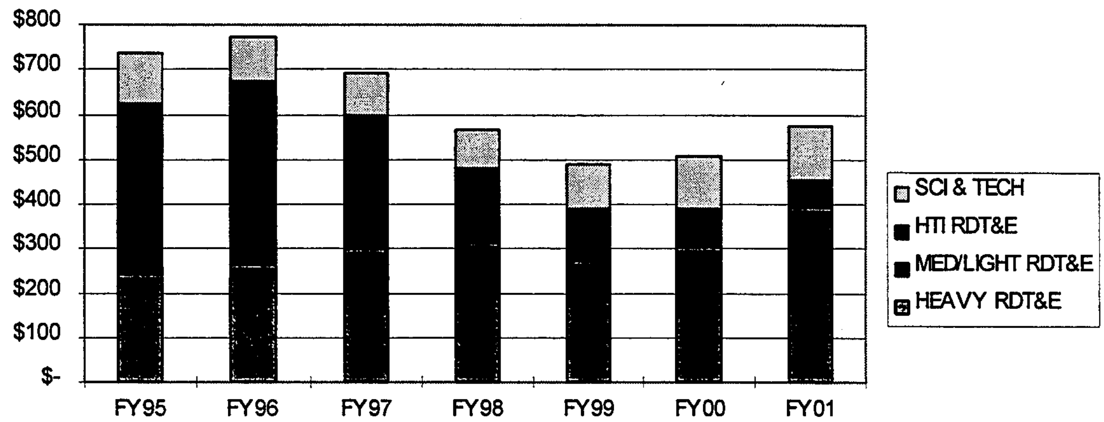
Research and development investments are necessary to improve TCV warfighting capabilities. Figure ES-2 shows the Department's total research and development funding broken down into two categories: science and technology[5] and weapon systems development.[6] In the figure, weapon systems development is further broken down into heavy, medium/light, and Horizontal Technology Integration (HTI)[7] RDT&E.

[5] Science and technology describes research and application development activities that include 6.1, 6.2, and 6.3A RDT&E funding budget categories.

[6] Weapon systems development describes 6.3B and 6.4 RDT&E funding budget categories.

[7] Horizontal Technology Integration (HTI) programs are subsystem level development efforts (6.3B and 6.4 RDT&E) that the Department has leveraged across a family of systems.

Figure ES-2: **TCV Research and Development Funding (1995 Constant $M)**



Source: U.S. Army and Marine Corps, and 1996-97 President's Budget, dated February 1995

The Department has identified five functional areas needed to improve TCV performance capabilities: mobility, lethality, survivability, command control and intelligence, and sustainability/crew-machine interface. Within each functional area, investment begins with science and technology activities associated with technology thrust areas. The technologies that show promise are incorporated into advanced technology demonstrators (ATDs). ATDs are designed to prove technologies before applying them to existing or new vehicle concepts.

Between 1995 and 2001, the Department plans to spend approximately $4.3 billion developing new technologies and integrating them into TCV weapon systems to improve military capabilities. About forty-four percent of these funds will be allocated to develop the new Crusader program (a heavy advanced self-propelled artillery system), five percent to other heavy TCV programs, twenty-five percent to medium/light TCVs, ten percent to HTI programs, and sixteen percent to science and technology development. The Army is evaluating the need to increase HTI funding to support future close combat missions. Army medium/light weapon system development funding is scheduled to end in 1999.

Sustainment

DoD's ability to support readiness of fielded TCV systems is at an all time high. Inventory levels for spare and repair parts are approaching 90 percent of their target levels. The rise in inventory is a result of force structure reductions, decreases in war reserve requirements, excess materiel from Operation Desert Storm, and improved business practices, such as stock funding of depot level reparables. High inventory levels, although positive from an operations perspective, have reduced revenues for some TCV suppliers. Whereas the Department spent approximately $600 million a year for sustainment and repair parts before Operation Desert Storm, it will spend only $160 million in 1995.

The lower funding levels suggest the Department will rely on fewer suppliers as some leave the business due to lower volumes. The Department does not expect to lose any specific required industrial capability. However, the TCV industry will take several years to size itself to the new funding levels. In the interim, DoD will monitor TCV suppliers to ensure necessary sustainment capability.

Contractors provide engineering advice and redesign expertise to resolve problems encountered during fielded TCV operation and maintenance. The Army generally requires and funds this sustaining engineering activity, termed "system technical support," as part of the production effort, and does not budget for it separately. Funding this capability as part of production has not been a problem because production levels through the 1980s were adequate to accommodate required sustaining engineering activities. However, as production volumes decline, the funding available for sustaining engineering also declines. In light of declining production requirements, the Army is examining alternatives to ensure that adequate TCV sustaining engineering capabilities are available.

TCV Manufacturers

Two prime contractors (operating a mixture of contractor and government owned facilities), five government depots, and two government arsenals comprise "the top level" of TCV industrial capabilities. These contractors, depots, and arsenals are involved in various aspects of the design, manufacture, and support of TCVs. The two prime contractors provide research, design, and manufacturing capabilities. They also provide business and vendor management capabilities integral to TCV design and fabrication. The two primes are:

- General Dynamics Land Systems (a division of General Dynamics Corporation), and
- United Defense, Limited Partnership (a partnership between FMC Corporation's Defense Systems Group and Harsco Corporation's BMY-Combat Systems Division).

Seven government owned and operated facilities (5 depots and 2 arsenals) build, upgrade, and support selected TCV components and vehicles: Anniston Army Depot, Letterkenny Army Depot, Red River Army Depot, Marine Corps Logistics Base Albany, Marine Corps Logistics Base Barstow, Rock Island Arsenal, and Watervliet Arsenal.

Meeting DOD Requirements

U.S. TCV producers depend heavily on DoD business. Ongoing programs, coupled with prospective foreign sales of medium/light vehicles, generally will be sufficient to sustain required industrial capabilities. Weapon system development funding is focused primarily on the Crusader and Advanced Amphibious Assault Vehicle (AAAV) programs. Nevertheless, planned advanced technology demonstrators and funded research and development programs will sustain a level of TCV engineering capabilities just adequate to support TCV technology needs.

TCV prime contractors and suppliers are facing a difficult transition from the peak years of TCV production in the mid-1980s (approximately $6 billion per year) to the $1.1 billion to $1.6 billion annual procurement budgets anticipated for the foreseeable future. However, the two prime contractors that manufacture and assemble TCVs have been profitable (Table ES-3) in recent years, despite declining sales and excess capacity. Both prime contractors are consolidating operations and restructuring their business relationships with suppliers to improve efficiency. Both prime contractors also are developing the industrial capabilities to design, integrate, and fabricate both heavy and medium/light TCVs. DoD anticipates these firms will have sufficient business to sustain needed industrial capabilities.[8]

Table ES-3

Prime Contractor Profitability

	1994			1993			1992		
Company	Sales	Operating Income	Operating Margin	Sales	Operating Income	Operating Margin	Sales	Operating Income	Operating Margin
GDLS	$829	$111	13.4%	$872	$110	12.6%	$773	$89	11.5%
UDLP	$1,089	$160	14.8%	$1,335	$204	15.2%	$1,460	$236	16.1%

Sources: Company Reports

General Dynamics Land Systems has expressed concern about the fragility of the supplier base. As procurements have declined, suppliers of some TCV components have left the business. This is a normal business response to reduced demand. Nevertheless, despite substantial declines in the number of suppliers, DoD expects that component producers will be able to meet the Department's known requirements in the coming years. The Department is already taking steps to assure the availability of a small number of TCV components, and recognizes that it might have to spend time and resources to respond to unanticipated problems as they arise in the future.

[8] The Department plans to develop a TCV modernization plan to identify needed actions beyond 2001. The plan will address the aging TCV fleet, requirements for new and follow-on vehicles, and technology needs. This plan may lead to changes in projected Department requirements, particularly in technology areas.

Examples of instances where the Department has taken action to sustain supplier capabilities include:

- Abrams X1100 transmission - Allison Transmission
- AGT 1500 engine - Allied Signal
- V903 engine - Cummins Engine
- Track rubberizing - Goodyear

As procurement quantities decline, the Department will continue to monitor suppliers for particular end items to ensure TCV suppliers can maintain required industrial capabilities and quality.

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1.0 TRACKED COMBAT VEHICLES

Tracked combat vehicles (TCVs) are ground combat systems. Generally more mobile than wheeled vehicles, they can cross natural and man-made obstacles and urban terrain, in all weather conditions, while under enemy fire. TCVs fall into two weight classes -- heavy and medium/light.[9] Heavy TCVs weigh over 40 tons and are normally fabricated from steel. Medium/light TCVs weigh less than 40 tons and are normally fabricated from aluminum. Further, the future trend for structural materials is toward composites.

1.1 OPERATIONAL REQUIREMENTS

The Army and Marines use TCVs for four basic missions, all designed to win on the battlefield as quickly as possible. First, close combat TCVs (tanks, fighting vehicle systems, armored personnel carriers, and command and control vehicles) provide direct offensive power, transport troops, and integrate combat battlefield activities. Second, fire support TCVs (self-propelled artillery and multiple launch rocket systems) provide lethal, indirect firepower. Third, combat support TCVs (armored bridge launchers and armored engineer vehicles) provide operational assistance by crossing barriers and clearing or laying obstacles. Fourth, amphibious assault vehicles attack from the sea and provide the capability to continue the attack inland.

To accomplish these missions, TCVs must be highly mobile. They must be able to traverse rough terrain in any environment, under all weather conditions, and under enemy fire. All vehicles in a unit must have comparable mobility to permit rapid maneuvering. TCVs must be lethal. They must be capable of direct, indirect, direct support, and deep attack fire.[10] TCVs must be survivable. Survivability enhancement requirements include reduced signatures, electronic counter measures, effective armor, and minimized fuel. TCVs must transmit and

[9] Originally, there were three tracked combat vehicle classes--heavy, medium, and light. Over the years, increased operational requirements led to heavier armor, larger guns, and more complex fire control systems. The result has been increased weight, effectively reducing the number of classes to two.

[10] Direct Fire designates when a weapon is fired at a target within sight of the crew. Indirect Fire accounts for weapons fired at a target not directly observed by the crew. Direct Suppport Fire supports the maneuver force. Deep Attack Fire is the attack of enemy forces beyond the close combat area.

receive command and intelligence data on the battlefield to coordinate operations. TCVs and their crews must be supported during missions. Supportability considerations include adequate fuel, spares, and repair parts; training needs; and crew comfort.

1.2 HISTORY

Tanks

TCVs made their first appearance in the First World War. In the Battle of Verdun, the British began to use armored and armed tractors. Fearing that producing vehicles named "landships" or "armored fighting vehicles" might reveal their purpose, the British described them as "water tanks" for drought-stricken Africa. The American army did not immediately develop its own tanks, relying instead on French and British products. Their sole mission was to support aggressive infantry assaults.[11] Between 1918 and 1920, U.S. tank manufacturers produced approximately 100 of the British-designed Mark VIII heavy tanks (weighing about 44 tons) and 950 French Renault "6-Ton" tanks (a light tank that actually weighed about 7.5 tons).

When World War II erupted in Europe, the U.S. Army had no tanks in production. However, after the Nazi Wehrmacht demonstrated the Blitzkrieg, the U.S. Army restarted its dormant tank-production programs. In October 1939, the Army placed its first tank order with American Car and Foundry, a company that built railway equipment. Subsequent contracts also went to railway equipment manufacturers because these companies had equipment capable of handling, shaping, and cutting heavy steel components. In September 1940, the Army built an entirely new plant, the Detroit Arsenal Tank Plant (DATP), to be operated by Chrysler, especially designed and equipped to produce tanks. Within seven months, the plant delivered its first M3 medium tank. Chrysler went on to build 22,234 tanks of various models during World War II. In

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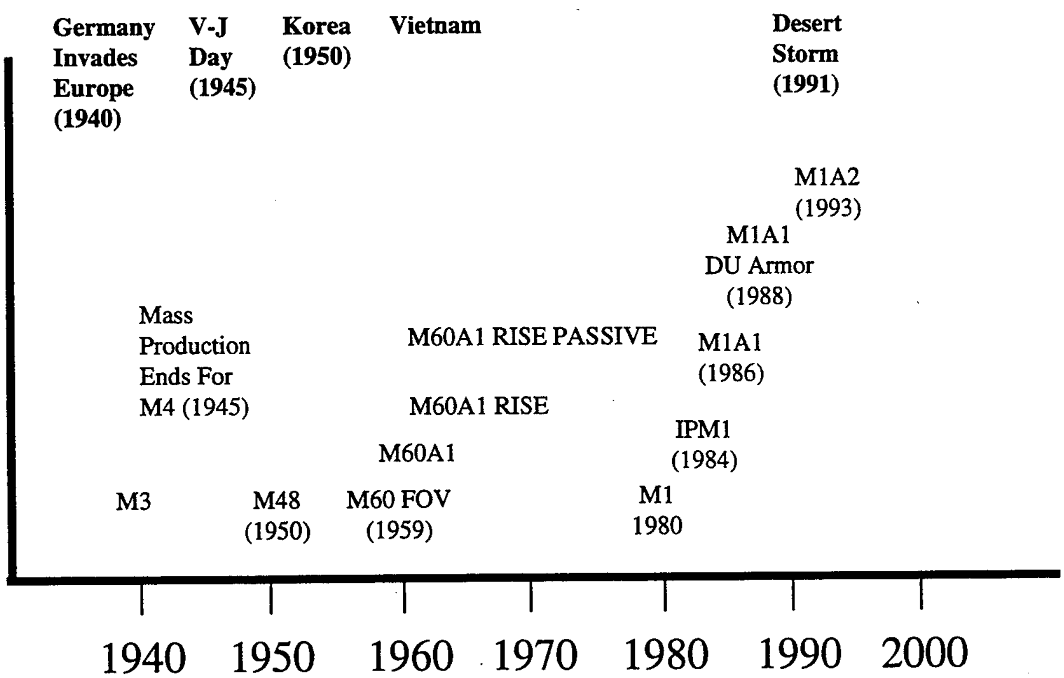
[11] The U.S. Army's first tank units formed in Europe during World War I. Inspired by an exciting recruiting poster imploring them to **"Treat 'em rough—Join the Tanks**," some of the best soldiers in the American Expeditionary Force joined the U.S. Tank Corps in early 1918 with then Captain George S. Patton, Jr. They built their force from scratch—recruiting men, acquiring facilities, devising doctrine and training, designing and procuring tanks from allies, and developing battle tactics. The men fought under tough conditions in hot, noisy, and cramped vehicles vulnerable to enemy fire and prone to breakdowns and miring. Lacking radios, the officers led on foot through the mud, exploding artillery, and machine gun bullets.

January 1945, the M46 Pershing heavy tank began to arrive in Europe. U.S. tank production during the war amounted to 88,410 tanks -- at a peak rate of over 1,800 per month. Figure 1-1 traces U.S. tank development and production since 1940.

Figure 1-1: **History of Heavy Tracked Combat Vehicle Class (Tank)**



RISE: Reliability Improved Selected Equipment

RISE PASSIVE: Reliability Improved Selected Equipment with Commander's and Gunner's Passive Sights

DU: Depleted Uranium

IPM1: Improved M1

After V-J Day, the Army halted mass tank production. While the automakers, tractor manufacturers, and locomotive builders reverted to peacetime pursuits, the DATP was converted to a government-owned, government-operated (GOGO) plant and, for five years, remained the nation's sole active tank manufacturing facility. Activities carried out at DATP included building prototype systems and modifing and remanufacturing existing models.

With new hostilities in Korea, Chrysler returned to operate the DATP as a government-owned, contractor-operated (GOCO) facility. Between 1950 and 1954, U.S. manufacturers (Chrysler, Fisher Body, and Ford) built 28,878 tanks, with nearly half of these being the M48 model. Other models fabricated included the M41 light tank, M103 heavy, M47 medium, and M26 to M46 conversions. After the Korean War, Chrysler continued to operate DATP. From 1960 to July 1982, Chrysler produced the M60 tank at DATP. In August 1976, the Army selected the Lima Army Tank Plant (LATP) facility, a new modern tank manufacturing site, as the initial production location for the M1 Abrams tank. Chrysler delivered the first two production units in February 1980. In 1982, General Dynamics Land Systems (GDLS) acquired Chrysler's Defense Division. By January 1984, GDLS plants produced seventy tanks per month. In 1985, GDLS supplied the Army with its first M1A1 -- the new main battle tank equipped with 120-mm cannon. One year later, the two GDLS plants achieved peak production with a combined total of 103 tanks per month. In late 1988, GDLS began producing M1A1s with depleted uranium armor for increased ballistic protection. With the end of the Cold War, tank production began to slow and GDLS delivered its last M1A1 from the DATP facility in September 1991. Since 1994, new production at LATP has been solely for foreign military sales. However, the Army has an active modernization activity to upgrade the U.S. tanks.

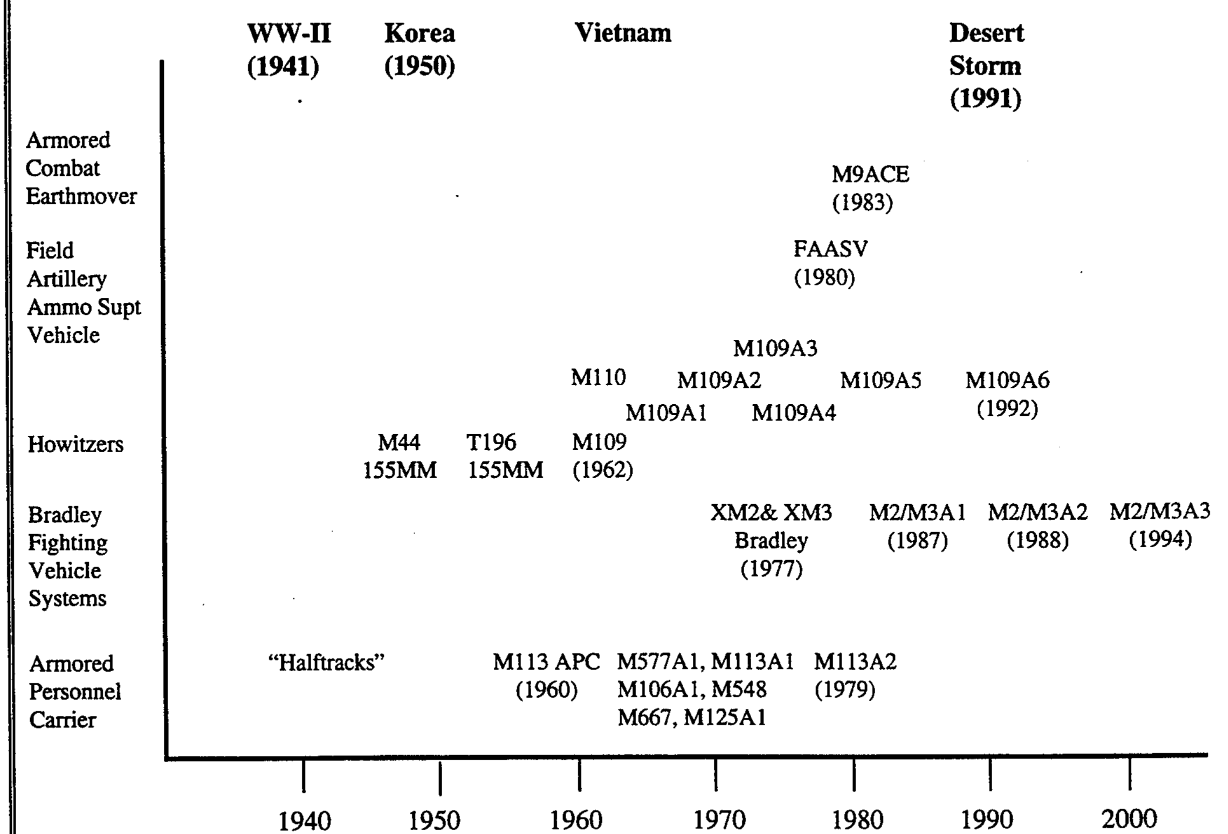
Other Tracked Combat Vehicles

After the success of tanks at the onset of World War II, the Army developed other mechanized, armored, close-combat vehicles. By V-J Day, various agricultural and trucking companies produced 21,000 high-speed tractors for towing guns and nearly 23,000 "half-tracks." Half tracks consisted of a lightly armored truck chassis with rear tracks for mobility and front wheels for steering. They served as gun motor carriages (when carrying machine guns or light artillery mobile mounts), tank destroyers (when mounted with heavier guns), and troop or cargo carriers (when hauling troops or cargo in combat zones).

After World War II, DoD continued to develop tracked vehicles for the close combat environment. These included armored personnel carriers, fighting vehicle systems, self-

propelled artillery, command and control vehicles, and support vehicles (Figure 1-2). For the most part, these vehicles have survivability and lethality requirements less stringent than those of tanks. Therefore, they are fabricated with aluminum, which makes them lighter, faster, and easier to deploy.

***Figure 1-2*: History of Medium/Light Tracked Combat Vehicle Class**



Amphibious Assault Vehicles

In 1941, the Marine Corps bought its first amphibious assault vehicle, the LVT-1, from FMC. During World War II, the Marines acquired approximately 11,000 amphibious assault vehicles of different configurations. Since then, the Marine Corps has procured roughly 2,200

more amphibious vehicles. In the mid 1980s, the Vietnam-era LVT-7 went through a Service Life Extension Program (SLEP) and was redesignated the AAV7A1.

Personnel Carriers

In 1960, the Army took possession of the first M113 armored personnel carrier. Since that time, the M113 has been modified into more than 40 specific variants (and entered service in more than 50 countries). Older M113 derivatives have been upgraded, reconfigured, and introduced as entirely new systems.

In 1981, FMC supplied the Army with the first Bradley. The Bradley is a mechanized personnel carrier armed with tube-launched, optically tracked, wire-guided (TOW) missiles and a 25-mm cannon. In 1986, FMC began the first block of improvements to the Bradley, including a central gas particulate system with individual face pieces for drivers, gunners, and commanders to protect against biological threats. In 1988, FMC began to outfit Bradleys (designated M2/M3A2s) with appliqué armor, spall liners, restowage, attachment points for armor tiles, 600 horsepower engines, TOW2 anti-tank missile systems, stabilized 25-mm cannons, coaxially mounted 7.62-mm machine guns, and modified transmissions. The Army has mounted, or plans to mount, other systems on the Bradley chassis -- the multiple launch rocket system carrier, the line-of-sight antitank system carrier, the Bradley Fire Support Team Vehicle, and the command and control vehicle.

Self-Propelled Artillery

The current series of self-propelled howitzers dates to extended Army efforts in the 1950s to field a replacement for the M44 155-mm howitzer. In 1956, the Army selected the M109 design. In 1961, Cadillac Motor Car Division of General Motors delivered the first two pre-production M109s and in 1962 delivered the first production vehicle. In 1964, Chrysler replaced Cadillac as prime contractor and in 1974, Bowen-McLaughlin-York (BMY)[12] replaced Chrysler.

[12] In 1994, Harsco's BMY Combat Systems Division and FMC's Defense Systems Group merged to become United Defense, Limited Partnership (UDLP).

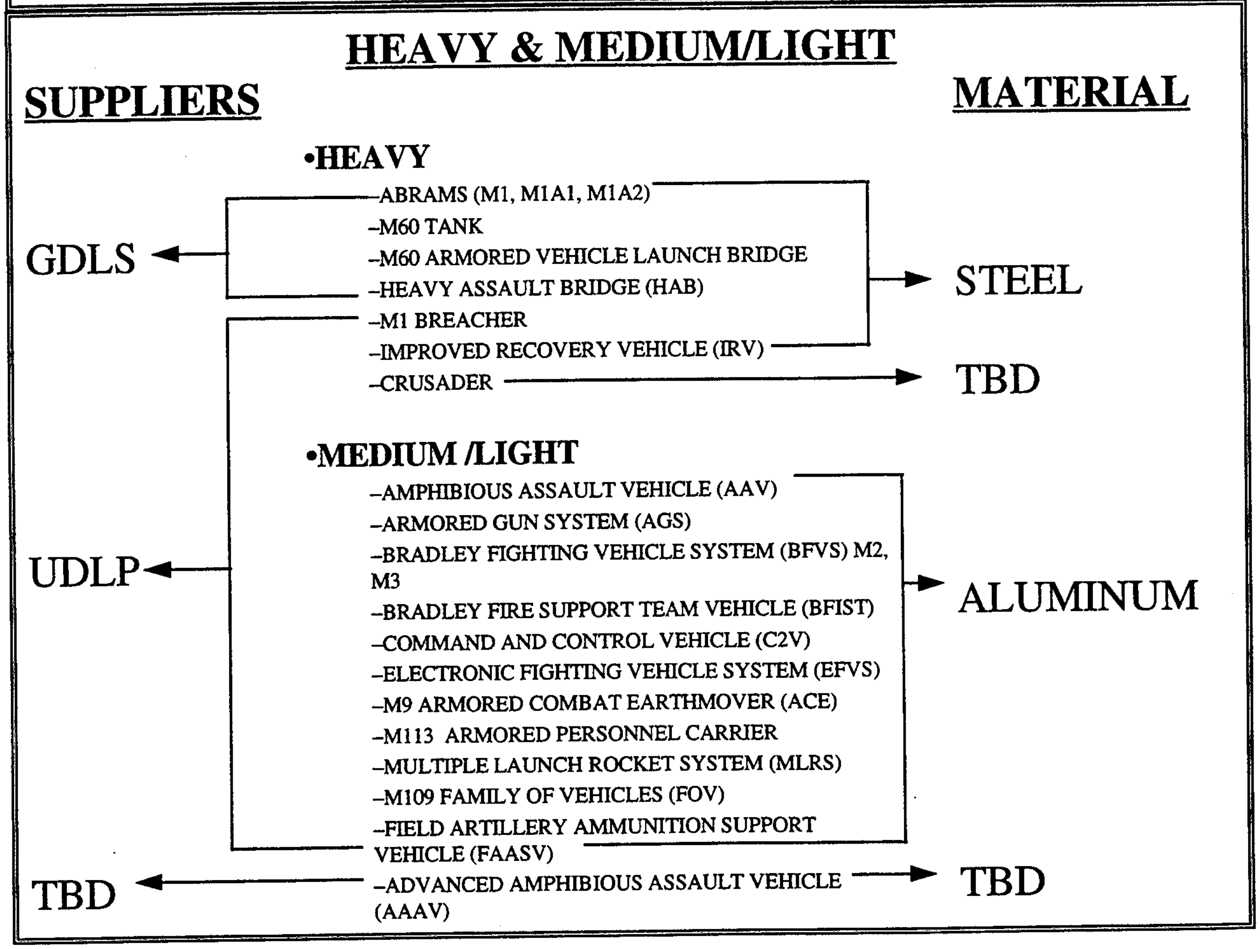
Together, these contractors have built more than 5,000 M109-series self-propelled howitzers of various configurations, including over 1,000 M109s for 25 foreign countries.

The M109A6 howitzer, now called the Paladin, is the latest configuration of the M109. In 1991, BMY began Paladin low rate production. The Army took delivery of the first production M109A6 in mid-1992 and plans to acquire 824 Paladins as a product improvement of the M109A2 and M109A3 howitzers. The prime contractor for the M109A6-series self-propelled howitzers is now UDLP. The balance of the M109 howitzer fleet will receive the M109A5 upgrade (automotive improvements; protection against nuclear, biological, and chemical (NBC) weapons; and M284 cannons). Also, a field artillery ammunition supply vehicle (FAASV) entered service with the Army in the early 1980s to support the M109-series of 155-mm self-propelled howitzers.

1.3 TCV WEIGHT CLASSES

TCV weight differences are the result of unique mission profiles for the various systems. The survivability, lethality, mobility, command and control, and sustainability requirements of each system determine its type of armor, weapons, electronics, powertrain, and suspension. Lethality and survivability largely determine if the vehicle will fall into the heavy or medium/light class. Figure 1-3 summarizes U.S. TCVs by class, producer, and material.

FIGURE 1-3
TCV SECTOR CLASS BREAKOUT



Heavy TCVs

The heavy class of vehicles, as shown in Table 1-1, includes the Abrams M1 series of tanks, the M60 tanks (now being phased out), heavy recovery vehicles, supporting systems used by combat engineers such as the Heavy Assault Bridge (HAB) and the Breacher, and the Crusader (formerly AFAS/FARV) self-propelled howitzer currently under development.

TABLE 1-1 HEAVY TCV CHARACTERISTICS						
	M1A2	**M60**	**M88/IRV**	**HAB**	**BREACHER**	**CRUSADER**
Purpose	Front Line, Close Combat	Front Line, Close Combat	Forward Position, Recovery Vehicle	Front Line, Close Combat Bridge	Front Line, Mine-Clearing Vehicle	Advanced Self-Propelled, Artillery System
Chassis Material & Weight	Steel (70 tons)	Steel (58 tons)	Steel (70 tons)	Steel (71 tons)	Steel (71 tons)	TBD
Engine Type and HP	Gas Turbine (1500 HP)	Air-Cooled Diesel (750 HP)	Turbocharged Diesel (1050 HP)	Gas Turbine (1500 HP)	Gas Turbine (1500 HP)	Gas Diesel (1200 HP)
Speed (Max)	45 MPH 30 MPH (Cross Country)	30 MPH	29 MPH (road)	45 MPH	41.5 MPH (Road) 5.5 MPH (Mineclearing)	TBD
Range	309 mi.	298 mi.	200 mi.	260 mi.	300 mi.	TBD
Weapons	120 mm gun 7.62 mm MG 12.7 mm MG	105 mm gun 7.62 mm MG 12.7 mm MG	M2 0.50 cal. MG	None	40 mm Gun 7.62 mm MG	155 mm (Regenerative Liquid Propellant Gun)
Target Acquisition	CITV, ICWS, LOS/DAHA	Laser Range Finder, Passive Night Sight, M21 Ballistic Computer System	None	None	Infra-red viewers	TBD
Armor	Steel-Encased Depleted Uranium	Steel	Steel	None	Modular Armor Panels, Radiation and Spall Liners	TBD
Countermeasures	NBC Warning/ Environmental Protection Unit	Radiac Warning System, NBC Air Filtration System, 6-Barreled Smoke Discharger, Smoke Generator	2 M239 Smoke Dischargers, Engine Smoke Generator, M13 Decontamination Kit	None	None	TBD

Abrams Tank

The M1A2 tank is the latest version of the Army's premier main battle tank. It is a fully tracked, low-profile, land-combat, assault weapon system possessing armor protection, shoot-on-the-move capability, and a high degree of maneuverability and tactical agility. It is the only U.S.

tracked vehicle that can withstand the impact of high-energy warheads and continue to fight effectively in high mobility and sustained operations. The four-person crew can close with and destroy enemy forces on the integrated battlefield using fire and maneuver. The Abrams tank is powered by a 1,500 horsepower turbine engine.

Breacher

The Breacher (now in development) will support ground forces by clearing simple and complex obstacles, such as wire, mines, tank ditches, and rubble. It will consist of a full-width, mine-clearing blade with automatic depth control, a power driven arm, and a commander's control station mounted on an Abrams chassis. It will possess mobility and survivability characteristics comparable to the Abrams tank.

Crusader

The Crusader (now in development) will combine the Advanced Field Artillery System (AFAS) and the Future Armored Resupply Vehicle (FARV) as replacements for the M109 self-propelled artillery and Field Artillery Ammunition Support Vehicle (FAASV) system. The AFAS portion of the system will provide responsive, supporting fire for the maneuvering ground forces. The Crusader will have advanced gun propulsion technology, high-speed automated-firing-data computation, round-to-round compensation, and automated ammunition handling to deliver precise firepower as part of coordinated unit missions or as independent, single howitzer missions. The FARV portion of the system will use "high pay-off technologies" in robotics, automation, and decision software to rearm the AFAS weapon system. The FARV's unique features include automated inventory control, robotic ammunition handling and rearm, refueling capability, crew-under-armor rearm, modern vehicular electronics, and NBC survivability features.

Heavy Assault Bridge (HAB)

The HAB system carries a 26-meter bridge with launching mechanism on a turretless, Abrams tank chassis. The bridge is capable of spanning up to a 24-meter gap on both prepared

and unprepared abutments. The HAB is the only mobile bridge system with sufficient load-bearing capacity for the Abrams tank.

Improved Recovery Vehicle (IRV)

The M88A1E1 Hercules recovers damaged Abrams tanks and other TCVs from the battlefield. The Hercules is an enhanced M88A1 with improved winch (70 tons vs 45 tons), winching (35 tons vs 25 tons), towing (70 tons vs 56 tons), horsepower (1,050 vs 750 horsepower), braking, steering, survivability, and suspension. Additional weight (70 tons vs 56 tons) gives the Hercules greater survivability than the M88A1. Also, the Hercules has an added 3-ton auxiliary winch to aid in the deployment of the main winch.

Medium/Light TCVs

Medium/light TCVs perform close combat and combat support missions. These missions include early entry personnel carriers, infantry support, obstacle removal, self-propelled artillery and rocket launchers for direct and indirect fire, and amphibious assault. The medium/light TCVs are listed in Table 1-2 and described below:

TABLE 1-2
MEDIUM/LIGHT TCV CHARACTERISTICS

	AAV7A1	AGS	BFVS	M9 ACE	M113 APC	MLRS	PALADIN
Purpose	Amphibious Assault, Troop Carrier	Close Combat	Close Combat Infantry Support	Engineer Vehicle, Obstacle Removal	Armored Personnel Carrier	Self-Propelled, Self-Loading, Multiple Launch Rocket	Mobile Artillery Support
Chassis Material & Weight	Aluminum (26.5 tons)	Aluminum (24.75 tons)	Aluminum (24.75 tons)	Aluminum (27 tons)	Aluminum (13.5 tons)	Aluminum (33.75 tons)	Aluminum (31.5 tons)
Engine Type & HP	Turbocharged Diesel (400 HP)	Diesel (580 HP)	Turbocharged Diesel (500 HP)	Diesel (295 HP)	Turbocharged Diesel (275 HP)	Turbocharged Diesel (600 HP)	Turbocharged Diesel (405 HP)
Speed (max)	40 MPH (Road) 8.5 MPH (Water Jets) 4.5 MPH (Water Tracks)	45 MPH (Road)	41 MPH (Road) 4.5 MPH (Water)	30 MPH (Road) 3 MPH (Water)	41 MPH (Road) 3.6 MPH (Water)	36.6 MPH (Road)	35 MPH
Range	300 mi. (Land)	300 mi.	300 mi.	200 mi.	309 mi.	300 mi.	214 mi.
Weapons	12.7 mm MG TOW 40 mm Grenade Launcher, or 7.62 mm MG	105 mm Gun 7.62 mm MG 12.7 mm MG or 40 mm Grenade Launcher	25 mm gun 7.62 mm MG 2-tube TOW Launcher (Firing Port Guns) 5.56 mm	None	12.7 mm MG	12 missiles (ready to use) 7.62 mm MG (Optional)	155 mm gun 12.7 mm MG
Target Acquisition	None	Laser Range Finder, two-axis stabilized day/thermal night sight, Hughes Infra-red Equipment	Automatic Dual Target Tracing, Auto Gun Target Adjustment, Auto Boresighting, Hunter/Killer Capabilities	None	None	Fire Direction System	Automatic Fire-Control System, Ballistic Fire-Control Computer and Navigation System
Armor	Enhanced Appliqué Armor Kit (Optional)	Modular Armor (Optional)	Aluminum (Optional) Appliqué Steel or Explosive Reactive or Passive	Aluminum, Kevlar and Steel	Aluminum, (Optional) Steel External Add-on Panels & Spall Liners	Aluminum, (Optional) Steel "Up Armor Kit"	Aluminum, (Optional) Steel and Kevlar Ballistic Linings
Counter-measures	Engine Smoke Generator	NBC Warning/ Environmental Protection Unit, Smoke Detectors	NBC Warning/ M13A1 Gas Particulate Filter System, M257 Smoke Dischargers, Engine Smoke Generating System	Smoke Grenade Launcher	NBC Warning, Smoke Grenade Launcher	NBC Warning/ Environmental Protection Unit	None

Amphibious Assault Vehicle (AAV)

The AAV7A1 is the U.S. Marine Corps' current amphibious assault vehicle. It travels both on land and water. The vehicle is powered by a Cummins, V-903, 400 horsepower, turbo-charged, diesel engine.

Advanced Amphibious Assault Vehicle (AAAV)

The AAAV (now in development) is the next-generation amphibious assault vehicle being designed for the Marine Corps. The AAAV is expected to increase water speed by three times, double the armor protection without appliqué armor, and possess significantly greater cross country mobility, agility, and speed than the current AAV7A1. The Marines expect it to enter production in 2006.

Armored Gun System (AGS)

The XM-8 AGS, with its three-man crew, is a fully tracked, lightweight, infantry-support, weapon system designed to replace the aging M551 Sheridan fleet in support of initial entry forces. The primary weapon, the XM-35 105-mm cannon, utilizes an autoloader.

Bradley (M2/M3)

The Bradley Fighting Vehicle System (BFVS) is a fast, agile, armored, infantry vehicle able to carry personnel and keep pace with the Abrams main battle tank in the field while simultaneously supporting infantry soldiers with added firepower. The M2 is the infantry variant and the M3 is the cavalry variant. The vehicle is powered by a Cummins V-903 engine.

Bradley Fire Support Team (BFIST) Vehicle

The BFIST (now in development) will provide artillery forward observation capability indirect fire support for the mechanized infantry and tank companies.

Command And Control Vehicle (C2V)

The C2V (now in development) is a mobile combat command and control enclosure integrated with a Multiple Launch Rocket System (MLRS) chassis.

Electronic Fighting Vehicle System (EFVS)

The EFVS is a mobile combat command, control, communication, and intelligence/electronic warfare enclosure integrated with a MLRS carrier. The EFVS includes an integrated power supply, environmental controls, NBC protection, and a remotely activated erecting mast.

Multiple Launch Rocket System (MLRS)

The MLRS is a mobile, self-propelled, self-loading, multiple-launch, rocket and missile firing unit used to increase standard artillery firepower. The MLRS is operated by a three member crew and is designed to operate in the "shoot and scoot" mode. It has many Bradley components.

M9 Armored Combat Earthmover (ACE)

The M9 ACE operates in forward areas with the lead tanks in a convoy. It can prepare defilade and protected positions for guns, tanks, and other critical battlefield systems. The M9 ACE can prepare combat roads, remove roadblocks, breach berms, prepare anti-tank ditches, and haul obstacle materials. It is powered by a Cummins V-903 engine.

M109 Family of Artillery

The M109 provides indirect fire support for the heavy divisions. The M109A2/A3 is the current base system. The M109A6 Paladin is an upgraded version which integrates an automatic fire control system and an inertial navigation system to reduce response time from approximately 10 minutes to less than one minute.

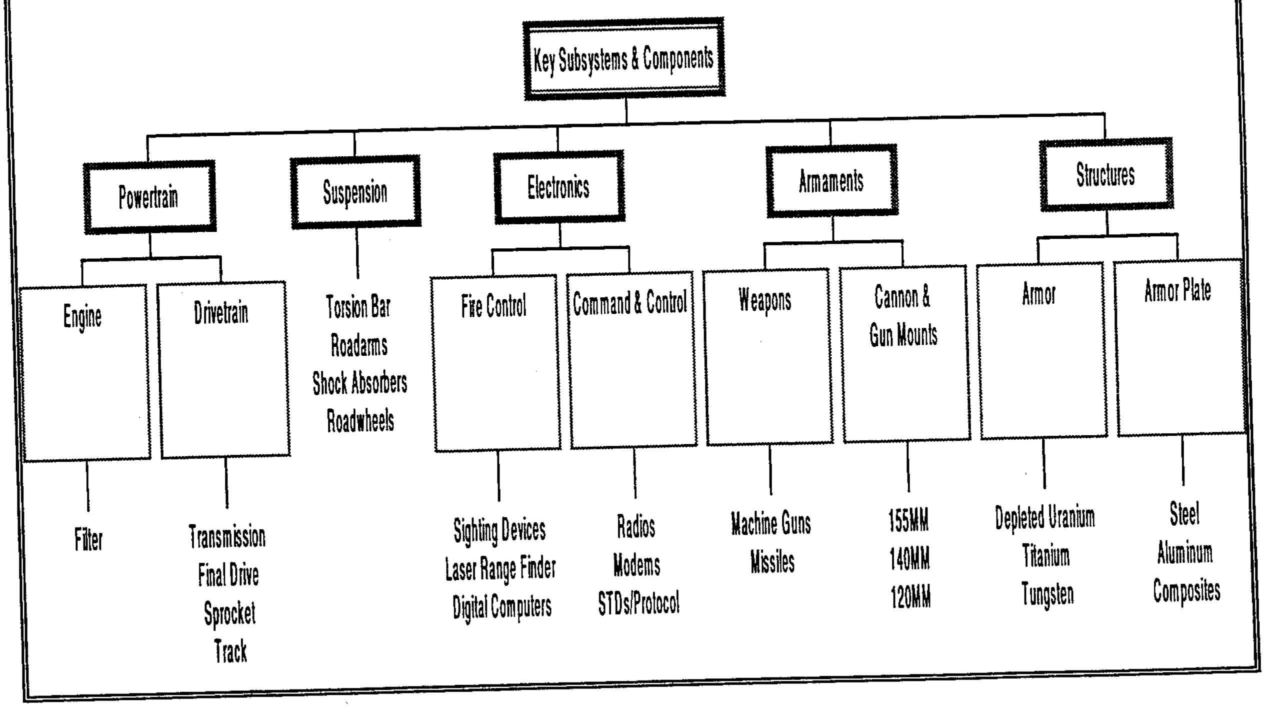
M113 Armored Personnel Carrier

The M113 is a fully tracked, armored personnel carrier designed to provide protected transportation and cross-country mobility for personnel and cargo.

1.4 COMPONENTS

The principal TCV subsystems and components found in both the heavy and medium/light classes are listed in Figure 1-4 and described below.

Figure 1-4: DoD TCV Subsystems & Components



Armaments

Armaments, not a part of this industrial capabilities assessment, provide firepower for the TCVs.

Electronics

Electronic systems are playing an increasingly important role in giving the U.S. TCVs their superior performance. Principal subsystems include:

- Command and Control. Command and control systems allow vehicles to communicate with, and pass tactical information to, other elements of the force and to control vehicle mobility and lethality functions. These systems vary from simple intercoms and radios to much more complex electronic systems for command and control of single or multiple vehicles. All TCVs have ruggedized command and control systems.

- Fire Control. The fire control system identifies, acquires, and tracks targets. Fire control precision is essential to ensuring a very high probability of first-round hit. Fire control systems include digital computers for acquiring, processing, and storing data; laser range finders for determining distance to target; and sighting devices such as the gunner's primary sight, gunner's auxiliary sight, and commander's independent thermal viewer for locating and acquiring enemy targets.

Powertrain

The powertrain consists of the engine and the drive train. The engines are primarily diesel, except for the AGT 1500 turbine engine used in the Abrams tank. The drive train is comprised of the transmission, final drive, sprockets, and track. The transmission -- a mechanical assembly of speed-changing gears, propeller shafts and housings -- transmits power, direction, and steering to the final drive and sprockets. The final drive converts power from the transmission through an over-fitting hub and sprocket which then drives the vehicle track. The track is the last component of the vehicle's drive system. Driven by the sprockets and guided by the roadwheels (an element of suspension), the track contacts the ground or water and enables the vehicle to move or swim.

Structures

TCV structures, the hull and turret, are composed of either aluminum (medium/light class) or steel (heavy class) armor plate fabricated using precise ballistic armor welding. In addition, some structures are augmented with additional armor, such as the Abrams tank with its very heavy depleted-uranium armor for additional crew protection and survivability. In the future, hulls and turrets may be fabricated from composite materials.

Suspension System

The suspension system allows the vehicle to move across varied terrain. Torsion bars serve as the springs on TCVs. There are normally 10 to 16 torsion bars per vehicle. Future vehicles, such as the AAAV, may utilize hydropneumatic suspensions in lieu of torsion bars. The roadwheel arms interface with the hull torsion bars and connect the hull to the roadwheels. The roadwheels keep the track aligned during its revolution around the sprockets. Roadwheels are mounted on the roadwheel arms and ride on the inner surface of the track shoe body. Suspension systems also include shock absorbers. Most TCVs use commercially derived, piston-operated, shock absorbers. The Abrams tank utilizes a rotary-type shock absorber.

1.5 INDUSTRIAL CAPABILITIES

The industrial capabilities required to produce TCVs are generally similar enough for heavy and medium/light vehicles that a manufacturer of one class could also manufacture the other class. Both prime contractors are developing the industrial capabilities to design, integrate, and fabricate both heavy and medium/light TCVs.

Design

The engineering capabilities most important to the design, fabrication, and support of TCVs are shown in Table 1-3. These capabilities range from mechanical, electrical, and welding to systems design and integration. Prime contractors are the only source of vehicle engineering and integration expertise for TCV systems design and fabrication.. Design and integration teams'

detailed knowledge differs for each class because of the complexities that exist as a result of mission and survivability requirements, the size and weight of the vehicle, and the size of the gun and ammunition and how it is handled. However, design teams working in either class could work in the other class if the requirements arise.

TABLE 1-3
IMPORTANT TCV ENGINEERING CAPABILITIES

CAPABILITIES	PRIME CONTRACTOR	TCV SUPPLIERS	DEPOTS
Systems engineering[1]	X	X	
Vehicle systems integration[2]	X		
Electrical	X	X	
Mechanical	X	X	
Welding	X	X	
CAD/CAM designers	X	X	
Metallurgists	X	X	X
Machine tool programmers	X	X	X
Machine & weld toolmakers	X	X	X
Electronics & optics	X	X	
Vehicle test	X		X

1. Systems engineering capabilities includes the prime contractor's software and design engineering expertise for vehicle systems and supplier provided subsystems.
2. Vehicle systems integration capabilities include the prime contractor's design integration and manufacturing integration skills.

At subsystem and component levels, both the primes and the suppliers have similar engineering skills, since both provide many of the same items. For example, GDLS provides not only primary structures such as the hull and turret, but also components such as the gunner's primary sight, improved commander's weapon station, gun mount, and gun trunnion. UDLP provides primary structures, both hull and turret, and components such as torsion bars, autoloading systems, and steel tracks. Also, at the maintenance level, the prime contractors have

many of the same engineering skills as the depots (who are responsible for repair) because the prime contractor provides sustaining engineering support to fielded TCVs.

Few of the engineering capabilities needed for TCVs are available from commercial suppliers (only communication and command and control). Commercial industry does not offer the specialized engineering expertise required to design and fabricate the heavy and medium/light armor structures, complex fire control systems, and sophisticated suspensions (see Table 1-4). Some engineering capabilities are available in other defense applications (CAD/CAM design, electronics & optics, electrical, and mechanical). For example, the aviation, missile and naval defense industries have design integration, command and control, fire control, and NBC protection engineering capabilities. However, some engineering capabilities (specifically those associated with heavy and medium/light armor structures, large mobile guns, and sophisticated powertrains and suspensions) are available only from TCV manufacturers.

TABLE 1-4
TCV ENGINEERING SKILLS & EXPERIENCE LEVEL COMPARISON

COMPONENT	TCV DEFENSE	OTHER DEFENSE	COMMERCIAL
Armor structure	X		
Armaments	X		
Command & control	X	X	X
Communication	X	X	X
Design integration	X	X	
Fire control	X	X	
NBC protection	X	X	
Powertrain	X		
Suspension	X		
Survivability	X	X	

Manufacturing

Prime contractors, key suppliers, and government facilities provide the manufacturing capabilities such as structures fabrication, ballistic armor welding, complex numerical control machining, systems integration, and assembly that are required to build, modify, and overhaul TCVs. Although obvious differences in manufacturing processes occur with respect to the

facilities required for steel or aluminum in categories such as cutting, welding, machining, and recycling, these differences do not preclude either prime contractor from bidding on any TCV contract or operating established government-owned TCV production facilities. The primes could change the specific tools and control programs used with their equipment to accomodate a switch between steel and aluminum if there were a need to switch manufacturing processes on the same factory floor. The differences do contribute to each class' particular mix of production equipment, such as cranes, hi-lows, computerized numerical control machines, automated welding equipment, and test equipment. Prime contractors have the capabilities shown in Table 1-5 to perform systems integration, structural fabrication, end item assembly, and final tests. Suppliers have the capabilities shown in Table 1-6 to manufacture components and in some cases integrate these components into subsystems. The Department has generally used its own depot facilities to repair, overhaul, and modify fielded systems. However, the Anniston and Letterkenny depots provide refurbished TCV components to the prime contractors for integration into the Abrams and Paladin upgrade vehicles (Table 1-7). Additionally, there are plans for Red River Army Depot to furnish Bradley components to UDLP. The Watervliet and Rock Island Arsenals manufacture new or modified components -- such as cannons, gun mounts, and recoil mechanisms for the Abrams and M109s -- and provide them as government furnished equipment to the prime contractors.

TABLE 1-5 TCV PRIME CONTRACTOR MANUFACTURING CAPABILITIES
Combat systems design and engineering expertise[1]
Combat systems integration expertise[2]
Propulsion and drive train integration
Complex stabilization and suspension development and integration
Steel armor structures design and fabrication
Aluminum armor structures design and fabrication
Armor ballistic welding expertise
Complex computer numerical control machining
Vehicle assembly line
Test track and system test

Notes:

1. System design and engineering expertise includes the prime contractor's software and design engineering expertise for vehicle systems and supplier provided subsystems.
2. Systems integration expertise includes the prime contractor's design integration and manufacturing integration skills.

TABLE 1-6 TCV KEY SUPPLIER MANUFACTURING CAPABILITIES	
COMPONENT	**CAPABILITY**
Depleted-uranium armor plate	Process for manufacturing depleted uranium billets required in support of armor production
Abrams turbine engine	Recuperator plate stamping process
Track/roadwheels	Rubberization process of adhering rubber compound to metal surface
Cannon	Rotary forge process
Torsion bars	Special manufacturing process
Fire control	Optical/electronic integration
Transmissions	Allison and Lockheed-Martin facilities
V-903 diesel engine	Cummins dedicated facility
Gun mounts	Dedicated organic and contractor facilities
Armor	Manufacturing process

TABLE 1-7 TCV MANUFACTURED COMPONENTS PROVIDED BY GOVERNMENT FACILITIES	
GOVERNMENT FACILITY	**VEHICLE & COMPONENT**
Anniston Army Depot	Abrams hulls to Lima Army Tank Plant for M1A2 upgrade program
Letterkenny Army Depot	Howitzer hull refurbishment for Paladin (M109A6) upgrade program
Red River Army Depot	Bradley upgrade program integrator (A1 to A2 conversion)
Watervliet Arsenal	Cannons for all TCVs
Rock Island Arsenal	Gun mounts and recoil mechanisms for the Abrams and M109 howitzer programs

2.0 WORLD MARKET

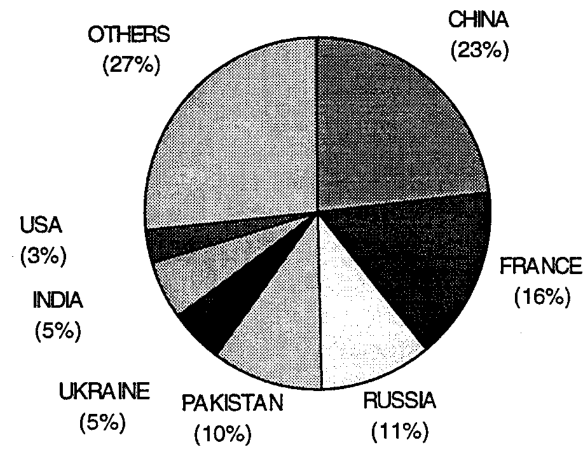
The number of TCV producers has grown over the last fifteen years. World production value of TCVs is projected to expand to $9.2 billion in 1999 from $6.4 billion in 1995, with most TCVs being procured to meet the producing nations' own requirements. The export market for heavy TCVs is limited. However, U.S. TCVs are superior and have proven wartime performance capabilities. U.S. producers are positioned to compete in the export market for medium/light class TCVs.

2.1 HEAVY TRACKED COMBAT VEHICLES (TANKS)

Heavy class production data is available only for tanks. Forecast International (a private market research and forecasting firm) projects total production value for new tanks[13] to be $50 billion between 1995 and 2003. The value of tank production is projected to increase 35 percent (from $4.9 billion to about $6.6 billion) between 1995 and 1999, before declining to about $4.6 billion in 2003. The projected value of tank production by country is presented in Figure 2-1.

[13] Projections are based on the following tanks: AMX LeClerc, Arjun, C1 Ariete, EE-T1 Osorio, Challenger, Kampfpanzer, Khalid, Leopard, M1A1/A2, Armored Gun System, M-84, Mark 3, Tamoyo, Merkava, Panzer, PT-91, SK 105, T.72, T.80, T.84, T.90, TR-125, Type 69-II, Type 80, Type 80-II, Type 85-II/IIM, Type 88, Type 90, and Type 90-II. Changes in anticipated sales for these tanks would alter the projections.

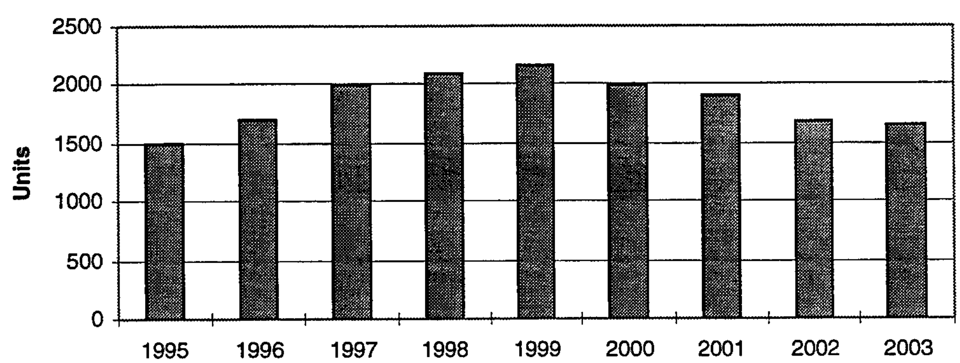
Figure 2-1: **World Tank Production Value (1995-2003)**
(Total Value: $49.9B)



Source: Forecast International/DMS Market Intelligence Report/Military Vehicle Forecast May 1994.

The world production for new tanks (Figure 2-2) is projected to increase from 1,503 to 2,153 units between 1995 and 1999. Production is then expected to decline to 1,642 units by 2003.

Figure 2-2: **World Tank Production (Units)**

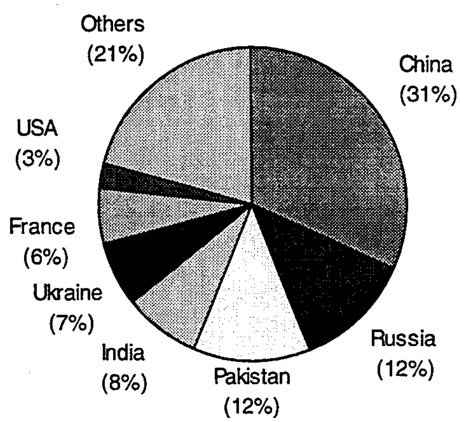


Source: Forecast International/DMS Market Intelligence Report/Military Vehicle Forecast May 1994.

Russia, Ukraine, China, India, Pakistan and other Asian nations are projected to build over 70 percent of new tanks. Western nations, by contrast, are upgrading their existing tanks over the next eight years. Prime examples are General Dynamics of the United States and Giat

Industries of France, which are involved in major modification programs of M1 and AMX 30 tank systems, respectively. Figure 2-3 shows the percentage of new tanks produced by country.

***Figure 2-3*: Tank Production (1995-2003) Total Units: 16,658**



Source: Forecast International/DMS Market Intelligence Report/Military Forecast May 1994.

The Army's Tank-automotive & Armaments Command (TACOM) estimates there is a potential for additional U.S. tank foreign military and direct sales totaling 404 vehicles. These sales include 150 M1A2 tanks for Saudi Arabia, 38 M1A2 tanks for Kuwait, 125 M60A3TTS upgrade tanks for Thailand, and 91 M60A3TTS upgrade tanks for Brazil.

Most tanks weigh over 55 tons, use steel armor, and have diesel engines. Only the U.S. M1 and Russian T80 tanks use gas turbine engines. The French LeClerc and German Leopard tanks use composite armor. The M1 tank's unit price ($4.2 million) appears to be competitively priced compared to the LeClerc ($8.5 million) and Israel's Merkava ($8.0 million), but not compared to Russian and Chinese tanks. With regard to performance characteristics, Russia's T80s have higher speed and range compared to M1 tanks. However, the M1 series tank has the most sophisticated fire control system in the world and has proven wartime performance. Table 2-1 summarizes key competitive characteristics of new tanks being produced today.

TABLE 2-1 KEY TANK COMPETITIVE CHARACTERISTICS								
Vehicle/ Country	Weight (Tons)	Speed (MPH)	Range (Miles)	Armor	Cannon (mm)	Engine	Crew	Unit Price ($M)
Leclerc/ France	60	44	341	Comp.	120	Diesel	3	$8.5
Challenger/ Britain	69	35	248	Steel	120	Diesel	4	$3.9
Chinese Tanks	53	39	253	Steel	125	Diesel	4	$2.2
T80/ Russia	48	47	409	Steel	125	Gas Turbine	3	$2.0
Leopard2/ Germany	69	45	342	Comp.	120	Diesel	4	$4.0
M1/ U.S.A.	68	42	280	Steel	120	Gas Turbine	4	$4.2
Merkava/ Israel	69	29	311	Comp.	105	Diesel	4	$8.0
Khalid/ Pakistan	53	39	257	Steel	125	Diesel	4	$2.8
Arjun/ India	64	45	-	Comp.	-	Diesel	4	$3.2

Source: Forecast International/DMS Market Intelligence Report/Military Vehicle Forecast January 1995.

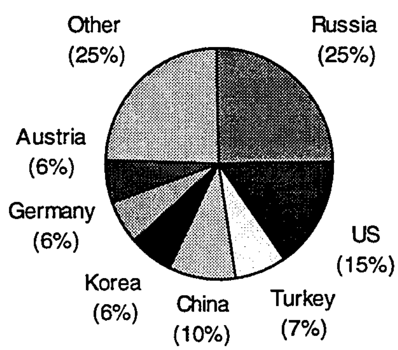
Competition

Although world production of new tanks is expected to increase, the prospects for exports are limited. First, most countries that buy tanks can also produce them. Asian nations, which account for over 70 percent of projected production, plan to meet most of their requirements through internal production. Some firms in developing nations have also begun producing tanks via coproduction and teaming arrangements with established firms, such as General Dynamics' M1A1 program with Egypt and Cadillac Gage's Jaguar tank program with China Machinery and Equipment. Second, older tanks produced by Western nations and the states of the former Soviet Union have been passed down to the armies of emerging nations. For example, American M48s, German Leopard 1s, and French AMX 30s have been passed down to the emerging nations; such transfers reduce the demand for new tanks, but do create demands for upgrades and sustaining engineering. Third, due to expensive development costs and budgetary constraints, Western nations are modernizing their existing tanks rather than developing and producing new ones.

2.2 MEDIUM/LIGHT COMBAT VEHICLES (TCVS)

Forecast International projects the value of production for medium/light vehicles[14] will increase 78 percent (from about $1.5 billion to about $2.7 billion) between 1995 and 1998, before declining to about $1.7 billion in 2003. The projected value and percentage of medium/light vehicle production by country is presented in Figure 2-4.

***Figure 2-4*: World Medium/Light Vehicles Value (1995-2003) (Total Value:$19.8B)**

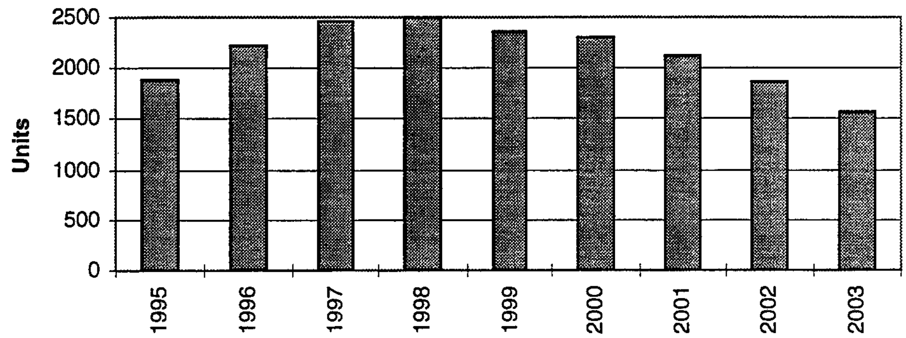


Source: Forecast International/DMS Market Intelligence Report/Military Vehicle Forecast May 1994.

The world unit production of medium/light vehicles (Figure 2-5) is projected to rise from 1,880 to 2,496 vehicles between 1995 and 1998, and then steadily decline to 1,561 units in 2003.

[14] Medium/light vehicles projections include Advanced Amphibious Assault Vehicles, AMX 10, AMX VTT, Armored Infantry Fighting Vehicle, Armored Vehicle 90, BMP.2, BMP.3, C 13, Cobra, EE-T4, Future Family of Armored Vehicles, FV101 Scorpio, FV 510 Warrior, Kampfschutzenpanzer 90, Korean Infantry Fighting Vehicle, M2/M3, M113, MARS 15, Puma, Schutzenpanzer Marder 2, second-generation Korean Infantry Vehicle, Stridsfordon 90, Type 63, Type 77, Type 85, Type 89, Type 90 Mechanized Infantry Combat Vehicle, Type WZ 501, Type WZ 503, Type YW 307, Type YW 309, Type YW 534, VCC-80, Vehiculo de Combate de la Infanteria, VPX 5000, Wiesel, and 4K 7FA. Any changes in anticipated sales for these vehicles would alter the projections.

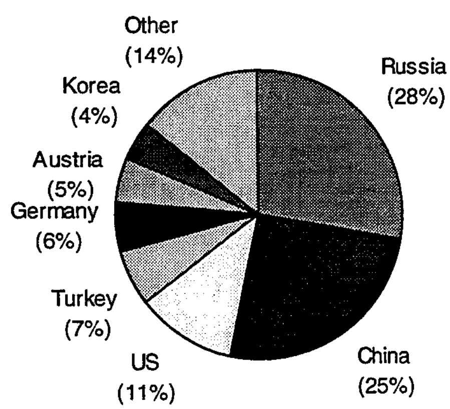
***Figure 2-5*: World Medium/Light Vehicles Production - (Units)**



Source: Forecast International/DMS Market Intelligence Report/Military Vehicle Forecast May 1994.

Figure 2-6 shows the percentage of medium/light TCV production by country.

***Figure 2-6*: Medium/Light Vehicles Production (1995-2003) (Total Units: 19,281)**



Source: Forecast International/DMS Market Intelligence Report/Military Vehicle Forecast May 1994.

The average unit price of new medium/light TCVs is projected to increase from approximately $800,000 in 1995 to $1.1 million in 1999, and then remain relatively stable

through 2003. This reflects increasingly sophisticated medium/light TCV armor, armaments, and fire control systems.

Competition

Worldwide, the number of medium/light tracked vehicle manufacturers has increased significantly over the last ten years, from 12 in 1985 to 36 today.[15] The Russian Federation and China are established producers striving to enter the world export market. The Russians and the Chinese have large facilities and offer competitive prices. The Republic of Korea, Turkey, and Pakistan also are entering the export market. The Army's TACOM estimates there is a potential for additional U.S. foreign military and direct sales totaling 1,644 vehicles of various types for six countries; including 194 for Thailand, 154 for Kuwait, 350 for Saudi Arabia, 116 for Japan, 42 for Israel, and 788 for Taiwan.

Table 2-2 summarizes key competitive characteristics of medium/light TCVs that are being produced today.

[15]Source: Forecast International/DMS Market Intelligence Report/Military Vehicle Forecast May 1994.

TABLE 2-2
KEY MEDIUM/LIGHT COMPETITIVE CHARACTERISTICS

Vehicle/country	Weight (Tons)	Speed (MPH)	Range (Miles)	Armor	Cannon (mm)	Engine	Crew	Unit Price
AMX13/ France	16.5	40	354	Composite	25	Diesel 280HP	3	$521K
BMP.3/ Russia	20.6	44	369	Aluminum	30	Diesel 500HP	3	$796K
C13/ Italy	16.1	44	311	Aluminum	25	Diesel 360HP	3	$1.25M
PersonnelCarrier/ China	15.9	40	311	Steel	-	Diesel 320 HP	2	$281K
Infantry Vehicle/ China	16.9	40	313	Steel	30	Diesel 360HP	3	$454K
Warrior/ Britain	28.3	47	410	-	30	Diesel 550HP	2	$1.3M
Kampfer/ Austria	27.8	44	373	Steel	30	Diesel 600HP	3	$1.3M
Infantry Vehicle / Korea	14.2	46	298	Aluminum	-	Diesel 280HP	3	$1.1M
Bradley/ USA	24.9	41	300	Aluminum	25	Diesel 500HP	3	$1.2M
Puma/ Germany	24.3	40	404	Steel	-	Diesel 429HP	2	$1.3M
Stridsn./ Sweden	24.7	44	186	Steel	40	Diesel 550HP	3	$1.3M
Type 89/ Japan	29.2	43	191		35	Diesel 600HP	3	$4.0M

Source: Forecast International/DMS Market Intelligence Report/Military Vehicle Forecast January 1995.

As with heavy TCVs, teaming and licensing arrangements are also used in the medium/light market to ensure survival in a highly competitive environment. Additionally, established firms are helping developing nations establish an indigenous capability (for example, United Defense, Limited Partnership and Nurol in Turkey, the Chinese in Pakistan, and the Russian Federation in India).

3.0 DOD REQUIREMENTS

The Department identifies requirements for TCVs in three key areas: (1) procurement -- buying new TCVs, TCV derivatives, or upgrades to fielded TCVs; (2) research and development[16] -- developing and integrating technologies and applications for future weapon systems; and (3) sustainment -- providing spare and repair parts to maintain field readiness. In general, requirements are oriented toward improving TCV performance against likely threat systems and maintaining TCV fleet readiness. All years mentioned in this report are fiscal years unless otherwise noted.

3.1 PROCUREMENT

Figures 3-1 and 3-2 reflect the build up during the middle 1980s and the decline in production requirements after the fall of the Soviet Union. Funding for TCV procurement declined 86 percent from $6.2 billion in 1983 to $0.9 billion in 1994 (1995 constant dollars).

[16] Research and development requirements and funding include 6.1, 6.2, 6.3, and 6.4 Department RDT&E funding categories. 6.1 is basic research and applied research, 6.2 exploratory development, 6.3 advanced development and 6.4 engineering development. 6.3 can be further broken out as 6.3A for the examination of alternate concepts and 6.3B for the demonstration and validation of a chosen concept. 6.1, 6.2, and 6.3A reflect Department funding for the research and development of a technology while 6.3B and 6.4 funds are associated with the development of weapon systems.

***Figure 3-1*: DoD TCV Procurement Funding**
(1995 Constant $M)

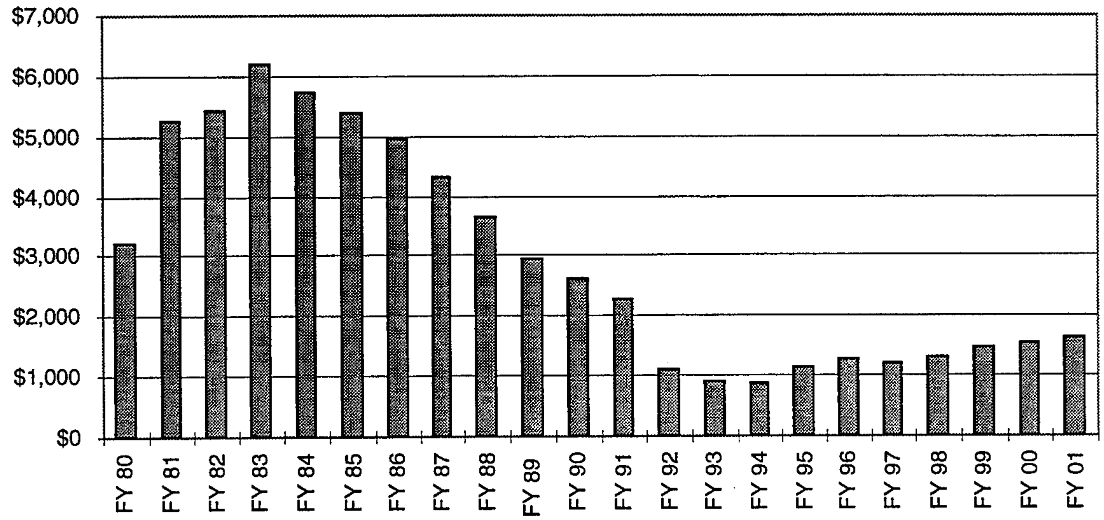
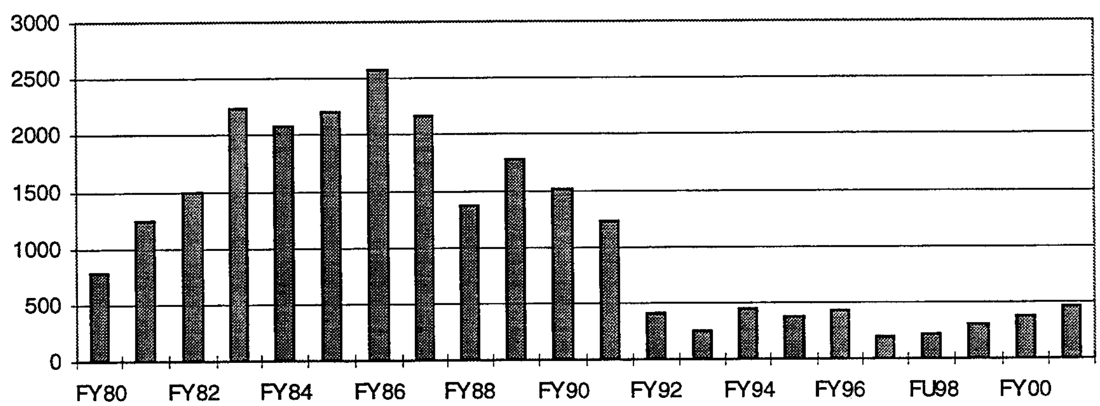


***Figure 3-2*: DoD TCV Production Units**



Source: U.S. Army.
Note: Units based on delivered year.

Between 1995 and 2001, annual procurement funding is planned to increase 46 percent from about $1.1 billion to $1.6 billion (1995 constant dollars). DoD plans to spend $9.2 billion for procurement, split about evenly between the heavy and medium/light classes. Table 3-1 summarizes production funding requirements by DoD program and heavy or medium/light class vehicles.

TABLE 3-1
TCV PROCUREMENT FUNDS
(1995 CONSTANT $M)

VEHICLE	1995	1996	1997	1998	1999	2000	2001	TOTAL
HEAVY								
Abrams (Marines)	0.0	0.0	5.6	0.0	0.0	0.0	0.0	5.6
Abrams (Army)	369.8	494.5	467.2	516.7	561.6	531.8	547.3	3,488.9
HAB	0.0	13.8	41.8	37.2	54.4	69.7	94.4	311.3
IRV (Army)	35.2	21.9	26.9	27.0	27.3	25.8	64.4	228.5
IRV (Marines)	0.0	0.0	0.0	0.0	38.6	38.6	38.6	115.8
Breacher	0.0	0.0	66.5	81.4	82.3	99.8	104.9	434.9
Marine Mods	3.3	3.1	3.5	3.6	0.0	0.0	0.0	13.5
SUBTOTAL	408.3	533.3	611.5	665.9	764.2	765.7	849.6	4,598.5
MEDIUM/LIGHT								
AAV7A1	2.8	10.8	13.0	13.0	13.1	0.0	0.0	52.7
AGS	0.0	129.7	168.3	157.8	220.3	188.3	145.8	1,010.2
BFVS	228.3	202.9	196.1	196.8	225.8	291.1	322.2	1,663.2
BFIST	0.0	0.0	0.0	17.2	22.6	27.5	31.5	98.8
C2V	0.0	0.0	26.9	32.0	60.0	72.7	102.1	293.7
M113 FOV	48.0	44.1	25.2	24.4	26.0	24.3	7.6	199.6
MLRS	175.7	67.3	42.7	39.6	61.1	107.4	137.6	631.4
M109 FOV	217.4	204.2	25.8	11.6	4.4	0.0	0.0	463.4
FAASV	9.4	3.8	4.4	1.3	0.3	0.0	0.0	19.2
SUBTOTAL	681.6	662.8	502.4	493.7	633.6	711.3	746.8	4,432.2
HTI	0.0	0.0	2.5	67.7	51.6	0.0	0.0	121.8
TOTAL	1,089.9	1,196.1	1,116.4	1,227.3	1,449.4	1,477.0	1,596.4	9,152.5

Dollars are from 1996-97 President's Budget dated February 1995, converted to constant 1995 dollars in millions. They include initial spares and modifications as well as the basic vehicle (upgrade) dollars for each vehicle or family of vehicles.

TCV production programs fall into three categories: new, upgrade/modernization, and derivative (Table 3-2). "New" programs are production vehicles based on new vehicle designs. "Derivative" programs are production vehicles based, at least in part, on existing vehicle designs and in some cases, include existing components. "Upgrade/modification" programs modernize

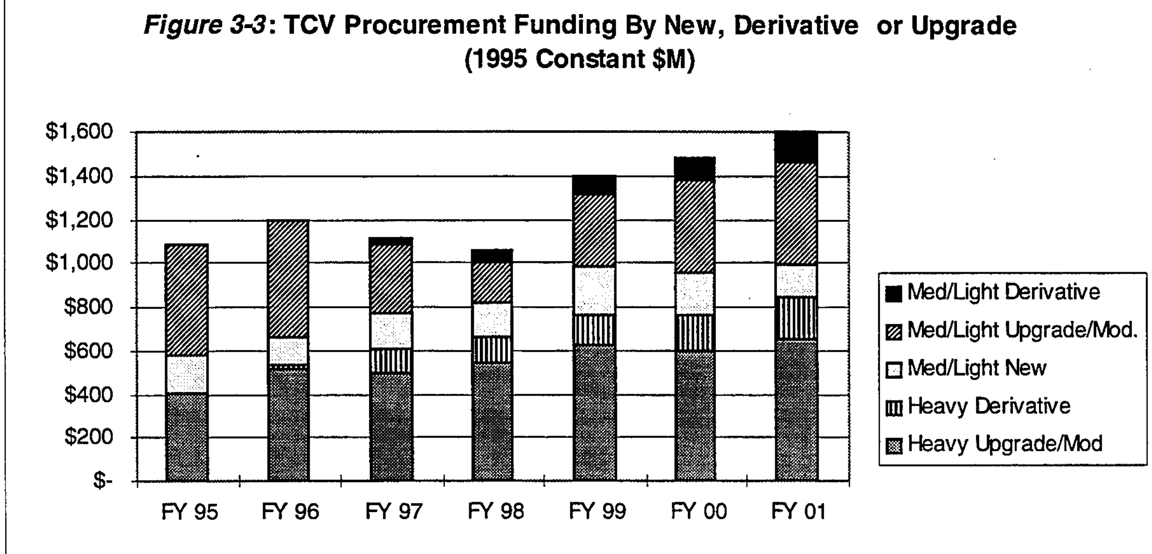
existing systems. There are two new, four derivative, and eight upgrade production programs planned.

TABLE 3-2
TCV PROCUREMENT CATEGORIZATION (1995-2001)

CLASS	NEW	DERIVATIVE	UPGRADE/MODIFICATION
HEAVY		HAB BREACHER	ABRAMS IRV
MEDIUM/LIGHT	AGS MLRS	BFIST C2V	AAV7A1 BFVS M113 FOV MLRS M109 FOV FAASV

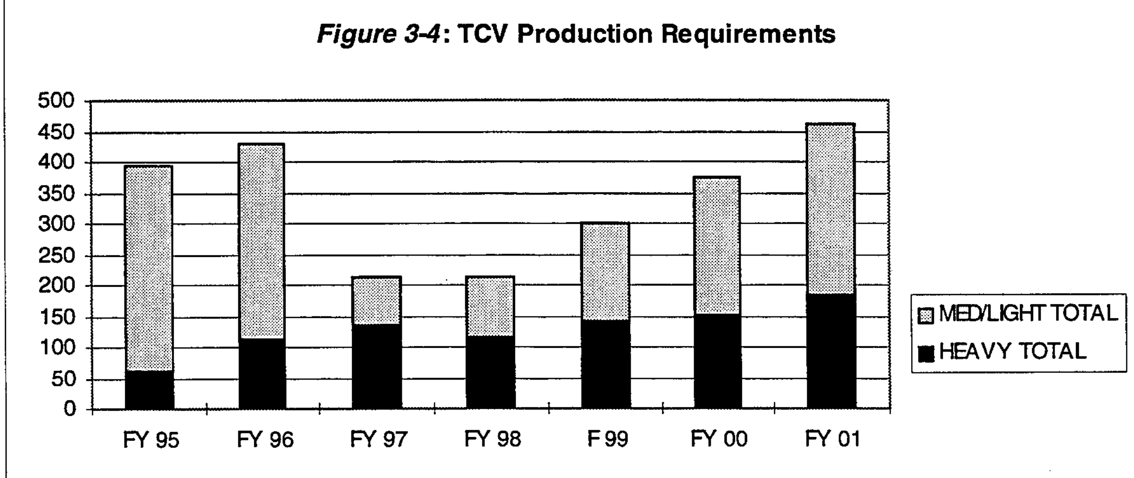
The distribution of TCV funds by program category is shown in Figure 3-3. HTI[17] funding is not included because it is spread over a range of program categories. The Department is spending 75 percent of its production funding during the 1995 to 2001 period on upgrade programs. This distribution is expected to change as new programs, the Crusader (heavy class) and Advanced Amphibious Assault Vehicle (AAAV) (medium/light class) begin production in 2004 and 2006.

[17] Horizontal Technology Integration (HTI) programs address those programs that the Department applies to a family of systems, rather than developing and producing unique systems. Examples of HTI programs are the second generation forward looking infrared sensor, eyesafe laser rangefinder, global positioning system, and battlefield digitization.



Source: 1996-97 President's Budget, dated February 1995

Figure 3-4 summarizes the Department's TCV production requirements for heavy and medium/light vehicles from 1995 through 2001. Table 3-3 breaks down the production requirements by specific program and heavy and medium/light class.



Source: 1996-97 President's Budget, dated February 1995.

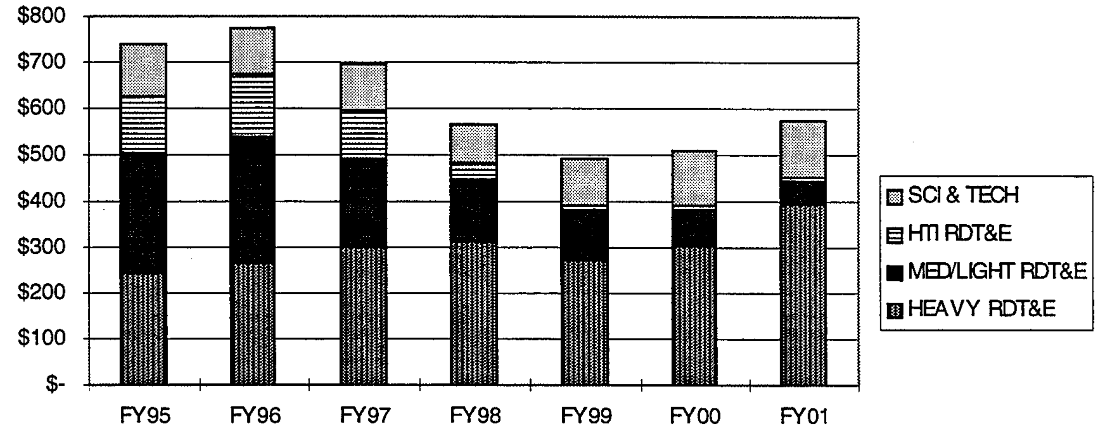
TABLE 3-3 TCV QUANTITIES								
VEHICLE	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**TOTAL**
HEAVY								
Abrams (M1A2)	46	100	80	80	97	96	94	593
M1A1 (Marines Upgrade)			24					24
HAB		3	11	10	17	22	30	93
IRV	15	9	12	12	12	11	35	106
Breacher			10	15	17	23	26	91
SUBTOTAL	61	112	137	117	143	152	185	907
MEDIUM/LIGHT								
AGS		26	42	33	40	40	35	216
BFVS	97	75	29	41	74	121	152	589
BFIST				15	27	41	53	136
C2V			6	6	17	21	35	85
MLRS	20							20
M109 FOV	215	215						430
SUBTOTAL	332	316	77	95	158	223	275	1,476
TOTAL	393	428	214	212	301	375	460	2,383
Quantities are from 1996-97 President's Budget dated Feb. 1995.								

3.2 RESEARCH AND DEVELOPMENT

Research and development investments serve to improve the warfighting capability of TCVs. Figure 3-5 shows the Department's total research and development funding broken down into (a) science and technology[18] and (b) weapon systems development[19] (heavy, medium/light, and HTI[20] RDT&E).

[18] "Science and technology" describes research and application development activities that include 6.1, 6.2, and 6.3A RDT&E funding budget categories.
[19] Weapon systems development describes 6.3B and 6.4 RDT&E funding budget categories.
[20] Horizontal Technology Integration (HTI) programs are subsystem level development efforts (6.3B and 6.4 RDT&E) that the Department leverages across a family of systems.

Figure 3-5: **TCV Research and Development Funding (1995 Constant $M)**



Source: U.S. Army and Marine Corps, and 1996-97 President's Budget, dated February 1995.

TCV Science and Technology

The Department seeks to improve TCV performance in five functional thrust areas: mobility, lethality, survivability, command control and intelligence (C2I), and sustainability/crew machine interface. Table 3-4 lists these technology thrust areas. Currently, the Department is not pursuing advances in C2I technology specifically for TCVs. The technologies which show promise in each thrust area are then incorporated into advanced technology demonstrators (ATDs). ATDs are designed to prove technologies in application demonstrators before selecting them for upgrades of existing vehicles or integration into new vehicle concepts. Science and technology funding is shown in Table 3-5. The Department plans to spend $111.3 million on science and technology and ATD activities in 1995 and $623.4 million during the FYDP. Contractor performed science and technology activities account for 65 to 75 percent of these funds.

TABLE 3-4

TCV TECHNOLOGY THRUST AREAS

Mobility	Lethality	Survivability	Command, Control & Intelligence	Sustainability/ Crew Comfort
Propulsion	Cannons-Tank-Artillery	Detection Avoidance	Communications - Intra Vehicle - Inter Vehicle	Environmental Control
Structures	Guns-Tubes & Control	Hit/Acq. Avoidance	Sensors	Resupply- Ammo- Fuel
Drivetrain	Missiles	Penetration Avoidance	Vision Devices	Embedded Training
Auxiliaries	Ammo-Propellants	Kill Avoidance	Warfighting Aids	
		Amphibious Concepts		

Source: U.S. Army and Marine Corps.

TABLE 3-5
TCV MISSION AREA SCIENCE AND TECHNOLOGY FUNDING
(1995 CONSTANT $M)

	1995	1996	1997	1998	1999	2000	2001
- Army	$85.8	$75.3	$68.5	$59.7	$81.8	$97.3	$101.1
- Marines	$6.1	$6.1	$8.0	$9.1	$11.3	$12.6	$12.6
- ARPA	$19.4	$19.0	$20.6	$15.2	$8.7	$8.4	$8.2
TOTAL	$111.3	$100.4	$97.1	$84.0	$101.8	$118.3	$121.9

Source: U.S. Army and Marine Corps and 1996-97 President's Budget, dated February 1995.
ARPA: Advanced Research Projects Agency.

Tables 3-6 through 3-9 identify the science and technology activities broken out by mission area. Table 3-10 lists the ATDs the Department is using to verify technologies.

TABLE 3-6
TCV MOBILITY SCIENCE AND TECHNOLOGY ACTIVITIES

TECHNOLOGY	NEED	SYSTEM APPLICATION	TECH. CATEGORY	FUNDED YEARS
Propulsion Engines - AIPS	Integrated, low weight, high performance power plant	Future MBT 50-Ton ATR	Advanced Development/ Applied Research	1984-1995
Propulsion Engines - Diesel	Low weight, high performance	All classes future vehicles	Exploratory Development/ Basic Research	1995-2000
Propulsion Engines - Electric Drive	Increased electric power, decreased vehicle weight	Scout Vehicle and Future Vehicles	Exploratory Development/ Advanced Development	1993-2001
Drive Train - Suspension (Adaptive/ Active)	Increased vehicle stability & maneuverability	All Vehicles	Advanced Development	1991-2000
Drive Train - Tracks (Light Weight, Linked Track and Band Track)	Increased cross-country speed, maneuverability, and track life	Bradley derivatives	Advanced Development	1994-1998

Objectives: Double the ride-limited cross-country speed of TCVs, cut the size and weight of mobility components by half, design lighter and more durable track, and significantly increase propulsion system power density.

AIPS - Advanced Integrated Propulsion System
ATR - Automotive Test Rig
MBT - Main Battle Tank

TABLE 3-7
TCV LETHALITY SCIENCE AND TECHNOLOGY ACTIVITIES

TECHNOLOGY	NEED	SYSTEM APPLICATION	TECH. CATEGORY	FUNDED YEARS
Cannons	Develop a lightweight intelligent armament system to increase rates of fire.	Tank 1080 FMBT	Advanced Development	1995-2001
Guns - Tubes & Controls (Gearless turret drive)	Replace hydraulic drives and improve accuracy	Abrams derivatives	Advanced Development	1995-1999
Guns - Tubes & Controls	Demonstrate improvements in MBT weapon stabilization	Tank 1080 FMBT	Advanced Development	1999-2001
Guns - Tubes & Controls	Autoloaders to achieve increased rates of fire	Tank 1080 FMBT	Exploratory Development/ Advanced Development	1999-2001
Guns - Tubes & Controls	Improve accuracy and rate of fire with crewman decision aids	Crusader	Advanced Development	1995-2001

Objectives: 1) Utilize advanced materials to reduce the weight of individual and crew served weapons; 2) Enhance penetration performance against conventional and explosively reactive armors with minimal environmental impact; and 3) Demonstrate new propellants which improve muzzle velocity and decrease sensitivity.

MBT - Main Battle Tank
FMBT - Future Main Battle Tank

TABLE 3-8
TCV SURVIVABILITY SCIENCE AND TECHNOLOGY ACTIVITIES

TECHNOLOGY	NEED	SYSTEM APPLICATION	TECH. CATEGORY	FUNDED YEARS
Hit Avoidance	Integrated suite of threat sensors and countermeasures	All vehicles	Advanced Development	1995-1997
Penetration Avoidance (Armor)	Defeat of top-attack munitions	All vehicles Crusader	Exploratory Development	1995-1997
Active Protection	Destroy or degrade penetrator/ warhead before impact	All vehicles	Advanced Development	1994-1999
Penetration Avoidance	Disrupt penetrating munitions	All vehicles	Exploratory Development	1994-1997
Smart Armor	Integrate smart sensors and armor defeat mechanism	All vehicles	Exploratory Development	1997-1999
Modular Armor	Develop rapid armor attachment methodologies	All vehicles	Exploratory Development	1994-1996
Simulation and Modeling	Model armor behavior under ballistic impact	All vehicles	Exploratory Development	1994-1998
Signature Management	Reduce threat capability to locate, acquire, or hit vehicles	All vehicles	Advanced Development	1994-2001
Non-ozone Depleting Substances	Environmentally safe fire suppressants	All vehicles	Exploratory Development	1995-1999
Composite Structures and Armor	Lighter weight combat vehicles	All vehicles	Advanced Development	1994-1997

Objectives: 1) Develop low cost, low observable systems to counter highly sensitive reconnaissance, intelligence, surveillance, target acquisition threat sensors and fuzed sensors in all regions of the electromagnetic spectrum; 2) Improve hit avoidance using sensors, countermeasures, and active defenses, for both top attack and horizontal threats; 3) Develop light weight ballistically efficient armors to include embedded sensors and active defeat components; and 4) Enhance NBC, shock protection, and fire suppression systems.

NBC - Nuclear, Biological, and Chemical

TABLE 3-9
TCV SUSTAINABILITY
SCIENCE AND TECHNOLOGY ACTIVITIES

TECHNOLOGY	NEED	SYSTEM APPLICATION	TECH. CATEGORY	FUNDED YEARS
Resupply Ammo	Ammunition resupply efficiency and rates must match battle action	Crusader	Applied Research	1995-2001
Advanced Controls, Displays and Expert Systems	Improved Crew-machine interface to reduce crew workload	All vehicles	Advanced Development	1994-2000

Objectives: 1) Improve functionality of crew stations by a) adapting intelligent associate technology to augment the crew member and demonstrate an integration methodology through progressive stages of analysis, design, and simulator evaluation; and b) developing mission-reconfigurable crew compartments and cockpits, real and simulator-based; 2) Improve combat service support system by a) developing an effective, total distribution management system with total asset visibility for all classes of supply; b) improving logistics communications and automation capabilities; and c) optimizing logistics force design, both structure and characteristics, to best support the Force Projection Army.

TABLE 3-10
TCV ADVANCED TECHNOLOGY DEMONSTRATOR PROGRAMS

The Composite Armored Vehicle (CAV) ATD will demonstrate the feasibility of producing lighter TCVs from advanced composites (1994-1997).

The Hit Avoidance ATD will demonstrate the effectiveness of integrated hit avoidance technology, to include sensors, countermeasures and active defenses, against both top attack and horizontal threats (1995-1997).

The Crewman's Associate ATD involves several Army Materiel Command organizations to demonstrate, through modeling and soldier-in-the-loop interactive simulator, crew station concepts utilizing advanced displays and controls which will enable soldiers to quickly understand and easily react to large amounts of information (1994-1996).

The Target Acquisition ATD will develop and demonstrate an extended range, multisensor target acquisition suite for future TCVs. Automation will reduce search timelines over manual search and streamline crew workload for future main battle tanks (1995-1998).

The Mobility ATD will demonstrate a new level of cross country mobility with significant improvement over the Abrams/Bradley baseline. It will include such components as active suspension, advanced motor and generator configurations for electric drive, continuous band track, and advance traction control (1997-2001)

The Combined Arms Command and Control (CAC2) ATD will demonstrate inter-vehicle communications. The output of this ATD will be future digitization of armor systems and will be a contributor to the Crewman's Associate ATD (1993-1995).

Specific Weapon System Development

Between 1995 and 2001, the Department plans to spend approximately $3.6 billion (in 1995 constant dollars) for TCV weapon systems development[21] (Table 3-11).

TABLE 3-11
TCV WEAPON SYSTEM DEVELOPMENT FUNDS
(1995 CONSTANT $M)

Vehicle	1995	1996	1997	1998	1999	2000	2001	Total
HEAVY								
Abrams	11.1	36.7	44.7	7.8	0.0	0.0	0.0	100.3
Crusader	199.2	200.0	243.4	290.3	263.0	304.2	396.2	1,896.3
HAB	11.6	9.9	1.0	9.3	0.0	0.0	0.0	31.8
IRV	4.5	2.9	0.0	0.0	0.0	0.0	0.0	7.4
Breacher	15.0	15.6	12.2	7.0	9.2	0.0	0.0	59.0
SUBTOTAL	241.4	265.1	301.3	314.4	272.2	304.2	396.2	2,094.8
MEDIUM/LIGHT								
AGS	53.5	44.3	21.0	14.7	0.0	0.0	0.0	133.5
BFVS	71.7	111.5	84.1	61.0	34.1	0.0	0.0	362.4
BFIST	17.6	21.9	19.3	3.5	0.0	0.0	0.0	62.3
C2V	30.2	17.2	6.3	6.2	0.0	0.0	0.0	59.9
MLRS	53.4	47.1	28.2	0.0	0.0	0.0	0.0	128.7
AAV7A1	4.2	1.0	1.0	1.0	1.0	1.0	1.0	10.2
AAAV	31.9	30.6	28.8	45.9	74.1	77.8	47.9	337.0
SUBTOTAL	262.5	273.6	188.7	132.3	109.2	78.8	48.9	1,094.0
HTI	123.0	135.7	106.5	34.3	8.7	8.4	8.2	424.8
TOTAL	626.9	674.4	596.5	481.0	390.1	391.4	453.3	3,613.6

Dollars are from 1996-97 President's Budget, February 1995, converted to constant 1995 dollars in millions.

These funds will be used to develop and integrate new or existing technologies into weapon systems in order to improve military "go to war" capabilities. Fifty-two percent will go to the development of the new Crusader program, five percent to other heavy TCV programs,

[21] Weapon systems development programs include 6.3B and 6.4 RDT&E funds for TCV vehicle development programs and HTI development programs.

thirty percent to medium/light TCVs, and the remaining to HTI programs (including the second generation forward looking infrared sensor, eyesafe laser rangefinder, global positioning system, and battlefield digitization). After 1999, no weapon system development funds have been programmed for the Abrams, HAB, IRV, AGS, BFVS, BFIST, C2V, MLRS, or AAV7A1.

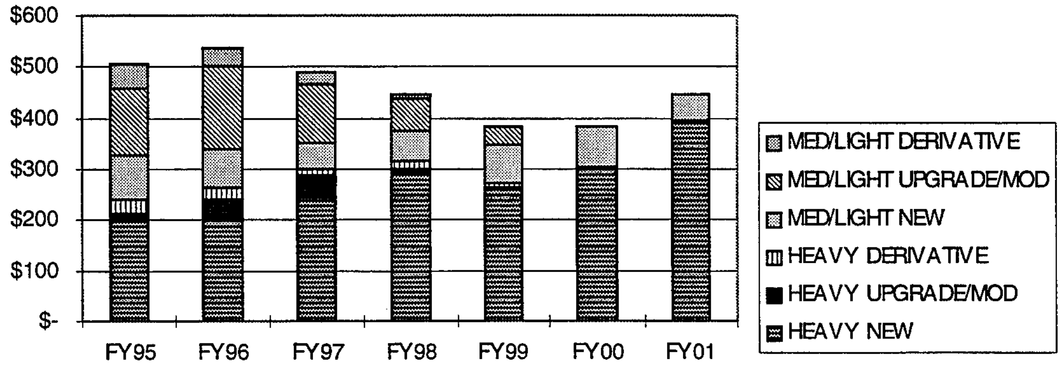
Table 3-12 categorizes the programs for which the 1995 through 2001 weapon system development funds are allocated. In the heavy class, both the HAB and Breacher are classified as derivatives because they use existing M1 structure designs. In the medium/light class, the Bradley Fire Support Team Vehicle (BFIST) and the C2V are classified as derivatives because both use Bradley chassis designs.

TABLE 3-12
TCV WEAPON SYSTEM DEVELOPMENT CATEGORIZATION

SECTOR CLASS	NEW	UPGRADE/MODIFICATION	DERIVATIVE
HEAVY	CRUSADER	ABRAMS IRV (HERCULES)	HAB BREACHER
MEDIUM/LIGHT	AGS AAAV	BFVS MLRS AAV7A1	BFIST C2V

Figure 3-6 characterizes TCV weapon system development funding by program category. HTI technology development funds are not included because they are spread over a number of program categories.

Figure 3-6: **Weapon Systems Development Funding (1995 Constant $M)**



Source: 1996-97 President's Budget, dated February 1995.

3.3 SUSTAINMENT

The TCV inventory (Table 3-13) requires sustainment for two different operating tempos: low during peacetime operations and high during a conflict. For example, the Abrams tank operates at a conflict tempo approximately 2.5 times its peacetime rate. War reserves (or contingency stocks) represent a "safety net" of stocks on hand at depots to support operations during a conflict. DoD generally procures war reserves in quantities over and above those necessary to meet peacetime operations to be able to satisfy high tempo conflict operations. Ongoing and projected production is a factor in determining the level of required war reserves. The DoD benefits from active TCV production because the prime contractor and, more importantly, the hundreds of subcontractors, have the requisite tooling and personnel to rapidly replenish required TCV components (such as was experienced during Operation Desert Storm). DoD is evaluating the availability of sufficient TCV spare parts based on (1) the extent to which there is an active production program, (2) the quantity of war reserves on hand, and (3) the anticipated demand, based largely on peacetime and conflict operations tempos.

TABLE 3-13
1995 TCV
INVENTORY

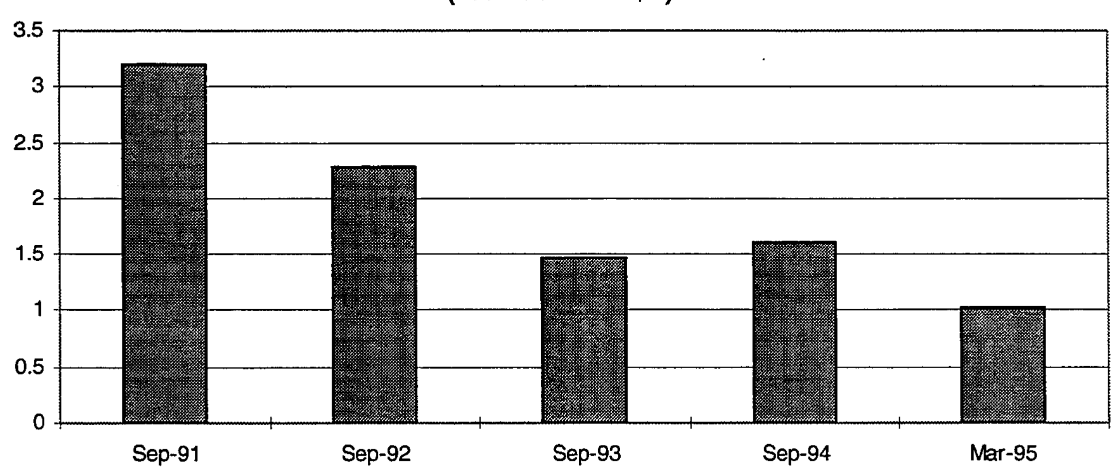
VEHICLE	SECTOR CLASS	PRIME CONTRACTOR	INVENTORY
ABRAMS (M1)	HEAVY	GDLS	3,268
ABRAMS (M1A1)	HEAVY	GDLS	3,716
ABRAMS (M1A2)	HEAVY	GDLS	62
ABRAMS (M1A1) (MARINES)	HEAVY	GDLS	379
M60 FOV	HEAVY	GDLS	921
M88	HEAVY		2,142
M88 (MARINES)	HEAVY		40
BRADLEY FOV	MEDIUM/LIGHT	UDLP	6,724
MLRS	MEDIUM/LIGHT	UDLP	687
M113 FOV	MEDIUM/LIGHT	UDLP	25,793
M109A6 PALADIN	MEDIUM/LIGHT	UDLP	210
M109 FOV	MEDIUM/LIGHT	UDLP	2,364
CEV	HEAVY		275
M9 ACE (ARMY)	MEDIUM/LIGHT	UDLP	482
M9 ACE (MARINES)	MEDIUM/LIGHT	UDLP	35
AAV7A1	MEDIUM/LIGHT	UDLP	1,322
FAASV	MEDIUM/LIGHT	UDLP	789

NOTE: Data obtained from U.S. Army and Marine Corps.

Spare And Repair Parts

The sustainment requirements objective for TCVs is the level of stock (spare and repair parts) inventory estimated to be necessary to support peacetime and conflict operations. Current (March 1995) DoD sustainment requirements (Figure 3-7) have declined 68 percent compared to September 1991 for three reasons: (1) force structure reductions; (2) stock funding of depot level reparables (DLRs); and (3) requirements reductions. First, the Department has reduced force structure from sixteen to ten active divisions. Sustainment requirements reflect the reduction in stocks required to support those divisions. Second, a new business approach intended to improve efficiency -- stock funding of DLRs -- requires the user to pay for depot level reparables from its budget. Direct user purchase of DLRs has increased maintenance process discipline. Instead of immediately requesting spare parts from the depot for suspect items, the user first attempts repair. Spares are requested only if cost-effective repair is not feasible. Third, requirements reductions -- such as spares pipeline reductions, are the result of instituting better business practices to reduce lead times, and adjustments resulting from new Defense Planning Guidance.

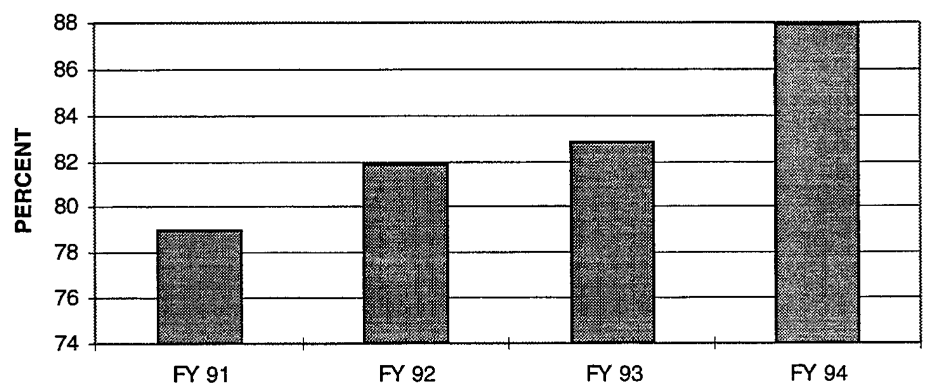
***Figure 3-7*: TCV Sustainment Requirements Objective (1995 Constant $B)**



Source: U.S. Army TACOM

Supply availability is a major indicator of the Army's ability to maintain fleet readiness and is based on the percent of requisitions (demands) that can be supplied from available stocks through the DoD supply system. Supply availability is currently at an all time high (Figure 3-8). Thus, even as the sustainment stock level requirements objective is lower, the Department has a high level of supplies on hand.

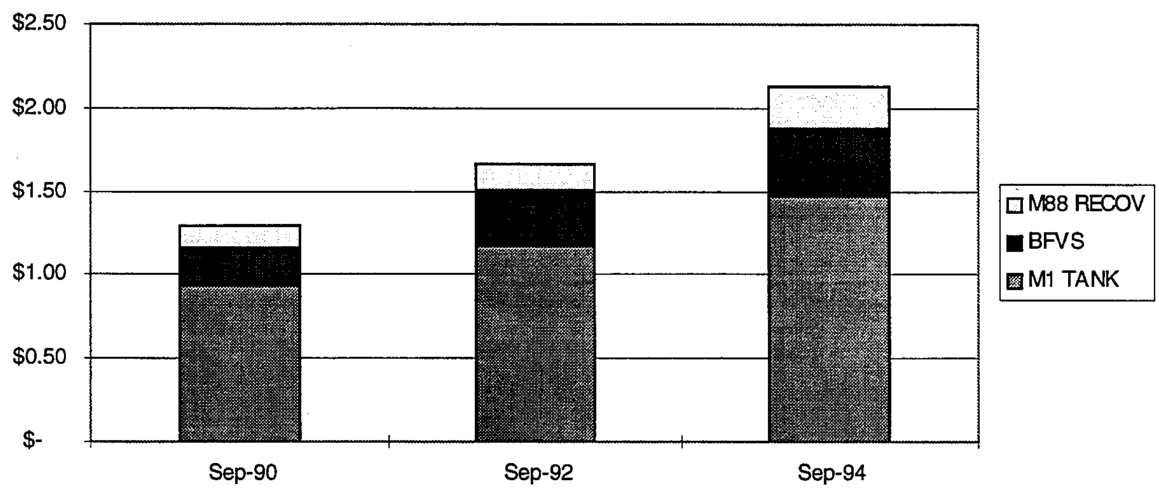
***Figure 3-8*: Supply Availability**



Source: U.S. Army TACOM

Figure 3-9 reflects the major TCV systems spares inventory levels for three important TCV systems from September 1990 to September 1994. The major combat systems (M1, BFVS, and M88) show an increase of $840 million, roughly 65 percent, during this period. The high level of spare parts inventories reflect residual materiel from the larger force structure of the early 1990s.

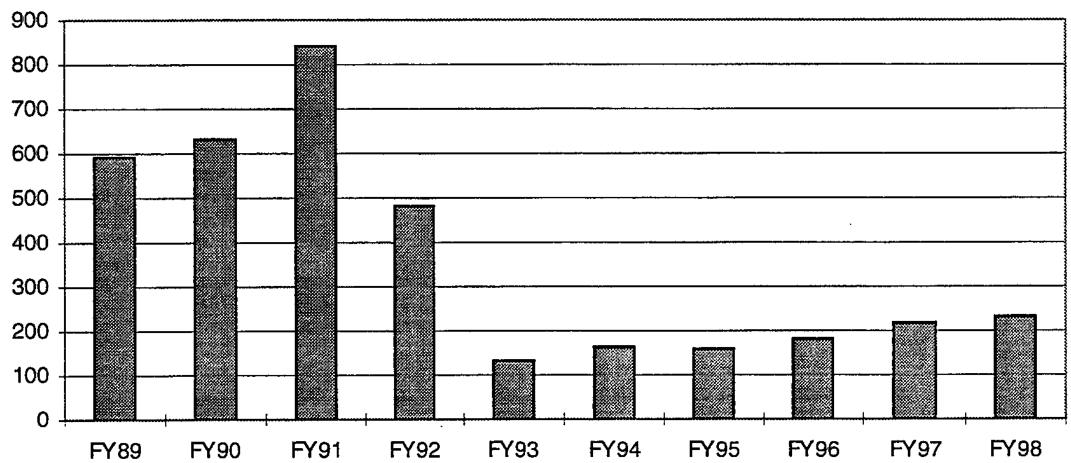
***Figure 3-9*: Tracked Combat Vehicle Spares Inventory Trend**
(Constant 1995 $B)



Source: U.S. Army TACOM

As a result of the excess inventory and reduced demands, TCV procurement funding for spare and repair parts (stock procurement) declined in 1993 and 1994. Figure 3-10 provides a six-year history of stock procurements and forecasts these actions through 1998.

***Figure 3-10*: TCV Sustainment Procurement**
(1995 Constant $M)



Source: U.S. Army TACOM

Sustaining Engineering

Contractors provide engineering and redesign expertise to resolve problems encountered during fielded TCV operation and maintenance. The Army generally requires and funds this sustaining engineering activity, termed "system technical support," as part of the production effort, and does not budget for it separately. Funding this capability as part of production has not been a problem because production levels through the 1980s were adequate to accommodate required sustaining engineering activities. However, as production volumes decline, the funding available for sustaining engineering also declines. In light of declining production requirements, the Army is examining alternatives to ensure that adequate TCV sustaining engineering capabilities are available.

4.0 TCV MANUFACTURERS

Two prime contractors (operating a mixture of contractor and government owned facilities), five government depots, and two government arsenals comprise "the top level" of tracked combat vehicle (TCV) industrial capabilities. These contractors, depots, and arsenals are involved in various aspects of the design, manufacture, and support of TCVs. DoD relies on private firms to sustain the skills, processes, facilities, and technologies required for TCVs. The two prime contractors provide TCV system research, design, and manufacturing capabilities, as well as similar capabilities for certain subsystems and components. In addition, the prime contractors provide business and vendor management capabilities that are an integral part of the TCV design and fabrication process. These two prime contractors sell exclusively to DoD and allied militaries. The two primes are:

- General Dynamics Land Systems (a division of General Dynamics Corporation), and

- United Defense, Limited Partnership (a partnership between FMC Corporation's Defense Systems Group and Harsco Corporation's BMY-Combat Systems Division).

Seven government owned and operated facilities build, upgrade, and support selected TCV components and vehicles: Anniston Army Depot, Letterkenny Army Depot, Red River Army Depot, Marine Corps Logistics Base Albany, Marine Corps Logistics Base Barstow, Rock Island Arsenal, and Watervliet Arsenal.

4.1 PRIME CONTRACTORS

Table 4-1 shows the current workloads of these prime contractors for new and upgraded vehicles.

TABLE 4-1
TCV MANUFACTURING BASE
QUANTITIES OF NEW AND UPGRADED VEHICLES

	FISCAL YEAR														
Vehicle	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**
GDLS															
Abrams	148	57													
Abrams Kits	91	32	32												
Abrams Upgrades[a]	95	111	71	76	82	97	97	94							
HAB				3	11	10	17	22	30	27	28	28	28	27	31
GDLS Total	334	200	103	79	93	107	114	116	30	27	28	28	28	27	31
UDLP															
Bradley	24														
Bradley Mod.[ab]	103	119	120	92	44	58	112	143	169	193	188	178	177	184	133
BFIST					15	27	41	53	54	52	48	33	33	28	
MLRS[a]	65	46	30												
C2V				6	6	15	21	34	42	79	82	82	67	5	
AGS			4	31	40	35	40	39	36	12					
M113 FOV[ab]	363	340	340												
Paladin[a]	116	162	214	216											
Hercules[a]		4	15	9	12	12	12	11	35						
M1 Breacher			14	46	46										
M9	91														
Crusader[c]			4	4	4	4	20	20	20	80	150	240	240	240	240
UDLP Total	762	671	741	404	167	151	246	300	356	416	468	533	517	427	373
TOTAL	1096	871	844	483	260	258	360	416	386	443	496	561	545	454	404

a. Designates an upgrade program.
b. A portion of the Bradley and M113 upgrades will be performed by Red River Army Depot.
c. UDLP is the prime contractor for Crusader through low-rate production (2004), teamed with GDLS, Teledyne Vehicle Systems, and Lockheed-Martin. The Government has the option to compete full-rate.

Source: Defense program offices.

The following sections describe the capabilities and business base for each top level TCV supplier.

General Dynamics Land Systems Division (GDLS)

GDLS, headquartered in Sterling Heights, MI, is the sole source producer of M1 Abrams main battle tanks. The M1 manufacturing program accounts for approximately one half of GDLS' total revenues.[22] GDLS' financial position, foreign military sales, facilities, and programs are summarized below.

Financial Position

In 1994, GDLS vehicle manufacturing earned $72.5 million on sales of $828.9 million -- a return of approximately 9 percent on sales and 54 percent on assets (Table 4-2). To maintain profitability as sales have declined, the company has initiated a number of streamlining efforts-- resulting in significant productivity increases. Net vehicle manufacturing sales decreased 5 percent in 1994, primarily due to the completion of a wheeled reconnaissance vehicle program in the fourth quarter of 1993, lower production levels of the M1 tank program, and scheduled reductions on the Egyptian M1A1 coproduction program. GDLS is seeking to supplement its volume by further expanding its international sales. GDLS may have additional opportunities for greater involvement in overhaul, maintenance, upgrade, and modification work.

[22] GDLS also manufactures SINCGARS radios, performs engineering work, and supports existing armored vehicles.

TABLE 4-2 GDLS FINANCIAL SUMMARY FOR VEHICLE MANUFACTURING			
FOR YEAR ENDED DECEMBER 31. DATA IN MILLIONS OF DOLLARS.			
Vehicle Manufacturing	**1994**	**1993**	**1992**
Net Vehicle Manufacturing sales	$828.9	$872.2	$772.9
Sales to U.S. Government	$817.1	$870.9	$759.1
Operating Income	$111.5	$110.3	$89.0
Net Income	$72.5	$71.7	$57.9
Identifiable assets	$135.2	$175.2	$158.7
Order backlog	$814.0	$693.7	$783.0
Employees	3,137	2,492	3,371
Operating Margin	13.4%	12.6%	11.5%
Return on sales	8.7%	8.2%	7.5%
Return on assets	53.6%	40.9%	36.5%
Net sales per employee	$0.26	$0.35	$0.23
Source: General Dynamics provided Vehicle Manufacturing financial data. They exclude other segments of the division's business and therefore sales, income, assets, backlog, and employees shown here are lower than the values shown on the company's 10K report on file with the Securities and Exchange Commission.			

Foreign Military Sales

GDLS produces Abrams tanks for U.S. allies in the Middle East. Saudi Arabia accepted the last of its 315 M1A2s during the third quarter of 1994. GDLS began production of 218 M1A2 tanks for Kuwait in 1994, at a rate of approximately 18 to 20 per month. Final delivery to Kuwait is expected in the first quarter of 1996. Egypt has accepted 25 complete M1A1 tanks and has contracted with GDLS for the manufacture of an additional 499 M1A1 kits through early 1997. GDLS has delivered 343 hull and 350 turret kits through the end of July 1995. Additionally, GDLS is also providing training and logistics support for these foreign military sales.

GDLS Facilities

GDLS operates five TCV facilities, as shown in Table 4-3. One of these facilities produces TCVs, three produce TCV components, and the fifth, GDLS' Central Office Complex (COC) headquarters in Sterling Heights, MI, performs design engineering, program management, purchasing, logistical support, and prototyping.

TABLE 4-3
GENERAL DYNAMICS LAND SYSTEM
DESCRIPTION OF FACILITIES

LOCATION	NUMBER EMPLOYEES	MFG & OFFICE SPACE (sq. feet)	PRINCIPAL PRODUCTS
Central Office Complex	1,377	446,000	Design Engineering, management, logistical support
DATP* Warren, MI	261	1,097,900	Component machining
LATP Lima, OH	1,015	1,630,446	Structure fabrication, assembly, and final test
Sterling Sterling Hgts, MI	231	162,500	Electronic components
Scranton Scranton, PA	253	313,600	Component machining
Total	3,137	3,650,446	

* Note: DATP has been recommended for closure by the 1995 Defense Base Realignment and Closure Commission.

Detroit Arsenal Tank Plant (DATP), Warren, MI

DATP is a government-owned, contractor-operated (GOCO) facility operated exclusively to produce defense products. DATP formerly produced entire vehicles, including the M60 and M1 Abrams tanks, but now produces M1A1 and M1A2 component parts such as trunnions and gun mounts. These components account for about 14 percent of GDLS' M1A2 upgrade efforts.

To make these components, DATP's major plant equipment includes a trunnion manufacturing cell, a gun mount machining center, and other computer and direct numerically controlled (CNC and DNC) machines, 99 percent of which are owned by DoD. DATP is currently operating at 37 percent of its total available capacity. DATP will be closed over the next few years if the Congress does not reject the recommendations of the 1995 Defense Base Closure and Realignment Commission. Its capabilities can be relocated and consolidated at other facilities.

Lima Army Tank Plant (LATP), Lima, OH

LATP is a GOCO facility operated exclusively to produce defense products. DoD owns 96 percent of the plant's equipment, including CNC machines, specialized machining centers, robotic welders, special fixtures, and test equipment. GDLS performs about 55 percent of the M1A2 upgrade work at LATP. It is the only U.S. facility that fabricates hull and turret structures and assembles main battle tanks. LATP has the capacity to produce 75 Abrams tanks per month operating three eight-hour shifts per day, five days per week (a "3-8-5" shift basis). The contractor has requested, and the Army approved a plan, to reduce its main battle tank capacity to 10 vehicles per month on a 1-8-5 shift basis. As a hedge against declining international demand for main battle tanks, GDLS is developing an aluminum and titanium welding capability at LATP so the facility can compete for medium/light TCV contracts.

Sterling Heights, MI

The Sterling Heights facility is a contractor-owned, contractor-operated (COCO) facility that assembles and integrates M1A2 electrical and optical equipment, including the gunner's primary sights, gunner's control and display panel, commander's integrated display, fire control electronic unit, radio interface units, driver's integrated display, hull power distribution units, Battlefield Combat Identification System (BCIS) installation kits, and various other hull switching and position sensors. GDLS performs about 18 percent of the M1A2 upgrade work at the Sterling Heights facility. GDLS is moving all Sterling Heights' manufacturing operations to other facilities.

Scranton Plant, Eynon, PA

The Scranton facility is contractor leased and operated. It has production, heat-treatment, paint, and test equipment. GDLS produces torsion bars, suspension housing, turret race ring assemblies, optical equipment, electrical housings, and hatches for M1A2 tanks at this facility. GDLS performs about 13 percent of the M1A2 upgrade work at Scranton.

GDLS Programs

Abrams M1A2 Main Battle Tank Upgrade

The M1A2 upgrade program is a cooperative effort between GDLS and the Anniston Army Depot (ANAD). Anniston disassembles the old M1 tanks, strips the hulls, destroys the old turrets, overhauls the AGT 1500 turbine engines, ships the X1100 transmission and fire control components to appropriate contractors for repair and upgrade, and ships the hulls and various components to Lima. GDLS converts the hulls to the M1A2 configuration, fabricates and assembles new turrets, installs new or overhauled government and contractor furnished material, joins the hulls to the new M1A2 turrets, and tests the completed tanks for compliance to performance specifications at the Lima facility.

The Army's acquisition objective is 1,079 M1A2 Abrams tanks. The original 62 new M1A2s plus the upgrade of its M1 Abrams tanks to the M1A2 configuration will fill this objective. The current upgrade program is scheduled through the year 2003, at an estimated cost of about $5 billion. GDLS began work in 1994 on the initial contract. By May 1995, the Army had accepted 57 upgraded tanks plus 4 pilot units; the pilots were upgrades that the Army tested more thoroughly than it did the later upgrades, but all 61 vehicles entered service. ANAD has shipped 92 refurbished hulls to Lima during the same period, giving Lima an adequate work-in-progress inventory to maintain its production rate. GDLS expects to complete the initial contract, for 210 M1A2 upgrades, in the third quarter of 1996. A second phase would add 792 upgrades to

be delivered during 1997-2003. The President's 1996 budget submission includes funding for the first 100 upgrades of the second phase.

In addition to the upgrade program, GDLS won an $85 million System Enhancement Program (SEP) contract in 1994 to improve the M1A2's electronics systems.

Heavy Assault Bridge (HAB)

GDLS and a German supplier, MAN GHH, won a $26 million, 39-month, engineering and manufacturing development contract in early 1994. GDLS will build two HAB prototypes in 1995 and will test the prototypes in 1996. GDLS will provide program management, system integration, and some manufacturing. MAN GHH will provide the bridge and the launching arm.

The Army will conduct a low rate initial production (LRIP) in-process review of the HAB in mid 1996. If the review is positive, LRIP vehicles could begin in October 1996, with three vehicles delivered in 1998, 11 in 1999, 10 in 2000, and 17 in 2001. Assuming acceptable performance for these initial vehicles, the Army would approve continued production in late 1999. The initial production rate will be sufficient to equip the first unit in early 2000. Production will increase to 22 units per year in 2001 and continue to increase to 32 units in 2010, the final year. The Army plans to acquire 106 HABs, with a potential value of approximately $260 million through 2004.

United Defense, Limited Partnership (UDLP)

On January 1, 1994, FMC's Defense Systems Group and Harsco's BMY-Combat Systems Division merged to form United Defense, Limited Partnership (UDLP). This combination, headquartered in Arlington, Virginia, established FMC as the managing general partner with a 60 percent equity interest and Harsco as the limited partner with a 40 percent

equity interest.[23] At the end of 1994, UDLP employed a total of 5,900 employees, including 1,300 from Harsco's former BMY-Combat Systems Division.

Financial Position

In 1994, UDLP earned $95.7 million on sales of $1,089 million -- a return of 8.8 percent on sales and 19.5 percent on assets. UDLP sales declined 19 percent from 1993 to 1994. UDLP has stated that it is reducing its manufacturing capacity and downsizing its operations to reflect both its new partnership and the reality of smaller defense budgets. Table 4-4 shows UDLP's financial summary.

TABLE 4-4
UDLP FINANCIAL SUMMARY

FOR YEAR ENDED DECEMBER 31. DATA IN MILLIONS OF DOLLARS.

	1994 UDLP	1993 Pro Forma	1992 Pro Forma
Net Sales	$1,088.7	$1,335.2	$1,459.8
Sales to U.S. Government	$618.3	$934.4	$970.5
Operating Income	$159.5	$203.7	$236.2
Net Income	$95.7	$138.4	$125.5
Total Assets	$492.0	$467.0	$454.7
Order Backlog	$1,412.3	$1,653.0	$1,740.8
Employees	5,911	7,204	7,909
Operating Margin	14.8%	15.2%	16.1%
Return on Sales	8.8%	10.4%	8.6%
Return on Assets	19.5%	29.6%	27.6%
Sales per Employee	$0.184	$0.185	$0.185

Sources: UDLP provided financial reports.
Note: 1993 and 1992 data includes both FMC's Defense Systems Group and Harsco's BMY Combat Systems Division.

Foreign Military Sales

[23] FMC records 100 percent of the partnership in its consolidated accounts while Harsco records the partnership as a minority interest.

UDLP is an international leader in the growing market for agile, transportable, lethal, and survivable medium/light tracked combat vehicles. The Russian Federation Arsenals, the Chinese State Arsenals, and foreign and American defense contractors are its main competitors for foreign military sales. Beginning in the last quarter of 1993, UDLP began deliveries to Singapore of M113 upgrade kits. These upgrades were essentially completed in 1994. UDLP also sold the M109 howitzer to South Korea, the Multiple Launch Rocket System to Japan, and the M113 armored personnel carrier to Kuwait. UDLP manages a joint venture in Turkey that produce armored fighting vehicles for the Turkish army. UDLP continues to discuss new contracts with Saudi Arabia, Egypt, South Korea, and Kuwait.

UDLP Facilities

UDLP is a diversified, technologically advanced defense prime contractor with eight facilities throughout the United States, as shown in Table 4-5. In the near future, UDLP plans to consolidate much of its tracked combat vehicle system production at York, Pennsylvania. York will also have the facilities and technologies to produce or upgrade medium/light and heavy TCVs. After the consolidation, UDLP will use the San Jose facility for research, development, and prototyping. The Aiken facility will provide parts and components.

TABLE 4-5 DESCRIPTION OF UDLP'S FACILITIES			
LOCATION	**NUMBER EMPLOYEES**	**MFG & OFFICE SPACE** **(sq. feet)**	**PRINCIPAL PRODUCTS**
Ground Sys Div, San Jose, CA	1,930	1,400,000	Aluminum tracked combat vehicles
Ground Sys Div, York, PA	1,280	990,000	Tracked combat vehicles
Ground Sys Div, Aiken, SC	273	200,000	Components
Armaments Sys Div, Minneapolis, MN	1,460	2,000,000	Armament systems
Steel Production, Anniston, AL	496	215,000	Component manufacturing
Paladin Production, Chambersburg, PA	54	90,000	Artillery vehicles
Armament Sys Div, Aberdeen, SD	56	120,000	Cannisters for missiles
Ground Sys Div, Fayette County, PA	54	180,000	Tracked combat vehicle disassembly
Total	5,603	5,195,000	

San Jose, California

The San Jose, California, facility is a COCO that has specialized engineering and manufacturing capabilities for medium/light tracked vehicles. These capabilities include aluminum-armor welding and assembly operations, advanced engineering, computer-aided manufacturing, three-dimensional modeling, stereolithography, technology development, and system integration. UDLP produces a declining portion of the Bradley Family of Vehicles, MLRS structures, the M113 family of vehicles, Command and Control Vehicles, Armored Gun Systems, Amphibious Assault Vehicles, EFVS, and various upgrade kits at the San Jose facility.

York, Pennsylvania

The York, Pennsylvania, facility is a COCO that designs, develops, prototypes, fabricates, and assembles M1 Breachers, M9 Armored Combat Earthmovers, M88 Improved Recovery Vehicles, M109 FOV, M992, and FAASV. UDLP is beginning to produce an increasing portion of the MLRS and Bradley upgrades at York. To perform this work, UDLP utilizes specialized engineering skills in tracked vehicle design, steel and aluminum armor technology, ballistic welding, manufacturing, system integration, quality assurance, and testing. York's plant equipment includes numerically controlled machines, automated welding equipment, machining centers, heat-treatment furnaces, testing equipment, and assembly fixtures.

Aiken, South Carolina

The Aiken, South Carolina, facility is a COCO facility that supplies over 4,000 machined and welded components (both steel and aluminum) for military and commercial applications. Defense work represents about 90 percent of Aiken's sales. The facility has seven work centers that include flexible manufacturing, automated machining, lathes, plate preparation and fabrication, general fabrication, and weld assembly. UDLP utilizes engineering skills such as mechanical design, precision manufacturing engineering, quality assurance, and material engineering at Aiken. The facility is currently operating at 70 percent of capacity, but the workload will likely increase when other operations are transferred to Aiken.

Minneapolis, Minnesota

The Minneapolis, Minnesota, facility is a GOCO facility. Its current workload is 72 percent DoD, 10 percent direct foreign sales, 17 percent FMS, and one percent other foundry and testing work. Its skills include heavy-gun technology, advanced engineering, system integration, and Crusader engineering. UDLP is currently designing and developing the Army's Crusader and the autoloader for the Armored Gun System at the Minneapolis facility.

Anniston, Alabama

The Anniston, Alabama, facility is a COCO that produces castings, forgings, track assemblies, torsion bars, suspension assemblies, suspension components, steel fabrications, and spare parts. Anniston also upgrades the M113 family of vehicles. Defense work represents about 85 percent of its sales. UDLP has specialized skills including foundry and forging engineering, mechanical design, metallurgical engineering, manufacturing engineering, welding, heat treatment, and quality assurance at Anniston. The facility is currently operating at 45 percent of capacity.

Chambersburg, Pennsylvania

The Chambersburg, Pennsylvania, facility is a GOCO that focuses on the M109A6 Paladin upgrade program. UDLP provides engineering and manufacturing skills such as manufacturing engineering, machining, welding, heavy metal fabrication, inspection, quality assurance, and testing at this facility.

Aberdeen, South Dakota

The Aberdeen, South Dakota, facility is a small plant that supports the Minneapolis, Minnesota, facility with components. UDLP predominantly fabricates cannisters for Navy missile systems at this facility.

Fayette County, Pennsylvania

Fayette County, Pennsylvania, is a company leased facility that supports the Ground Systems Division. UDLP uses the facility to disassemble tracked and wheeled vehicles scheduled for upgrades, such as the Bradley, FAASV, and MLRS.

UDLP Programs

Armored Gun System (AGS)

The AGS is a new generation, light, rapidly deployable, gun system under development by UDLP. UDLP began by designing, manufacturing, and delivering six XM8 AGS prototypes to the Army in 1994 from the San Jose facility. The Army will test these prototypes through 1996. LRIP of 26 vehicles should occur in 1998, with UDLP expected to machine the AGS hull and turret, fabricate its armor plate at the San Jose facility, and then ship the as-is structure to York. The York facility will perform integration, assembly, and acceptance testing.

The Army has scheduled full production of 211 AGS vehicles for 1999 through 2004. Production rates will increase to a peak rate of four vehicles per month. The initial production rate will equip the first unit in May 1999.

Bradley Fighting Vehicle

The Bradley Fighting Vehicle system has been the mainstay of FMC's Defense Systems Group since 1980, accounting for roughly 40-50 percent of total sales and 60-70 percent of tracked vehicle sales. So far in 1995, the Bradley has accounted for 28 percent of total sales and 50 percent of tracked vehicle sales. In 1994, UDLP produced 293 new Bradley M2A2s (181 U.S. and 112 Saudi). Final deliveries of new M2A2 infantry vehicles ended in February 1995.

Bradley Modernization Program

The Bradley Modernization program consists of four separate programs and is being performed both by UDLP and Red River Army Depot. First, Red River Army Depot is converting all Bradley A1 configured vehicles to the A2 configuration. This program is scheduled for completion by early 1998. Second, UDLP is converting 424 A0 configured vehicles to the A2 configuration by late 1998. Third, UDLP has contracted to modify 1,423 A2

vehicles with improvements identified as a result of Operation Desert Storm (ODS) (scheduled completion in 2001). The ODS improvements include a laser range finder, position navigation system, equipment restowage, combat identification system, and driver's all weather viewer. Finally, UDLP won the approximately $280 million development contract, which began in 1994 and will conclude in 1998, to convert 1,602 A2 vehicles to the latest technology A3 configuration. The A3 upgrade includes a second generation forward looking infrared sensor, battlefield digitization, and command and control improvements. Production will continue into 2010.

Bradley Fire Support Vehicle (BFIST)

In June 1995, the Army awarded UDLP the development contract for the BFIST. The BFIST replaces the M981 FIST vehicle and adds improvements identified as a result of ODS. The initial 180 plus production vehicles will use the existing Bradley A2 chassis with modified turret to accommodate the BFIST mission equipment. Production will run from 1998 through 2002. The Army plans a second phase for an additional 200 plus BFIST vehicles based on the Bradley A3 configuration, scheduled for 2002 through 2007.

Command and Control Vehicle (C2V)

The C2V is part of an Army concept to modernize the battlefield. UDLP won a $28 million contract in early 1995 to build four pre-production C2Vs on a MLRS chassis. In the forthcoming production phase, the Army forecasts delivery of about 430 vehicles between 1997 and 2005.

Crusader

The Crusader is the Army's largest weapon system development program. The Army chose UDLP as the Crusader's prime contractor. A team of GDLS, Teledyne Vehicle Systems, and Lockheed-Martin will assist UDLP in developing all armament, vehicle, expendable resupply, fire control, and command, control, and communication systems on the Crusader. This teaming arrangement is the first major program where UDLP and GDLS will be working together. UDLP estimates the value of the program's demonstration and validation phase at $1.2 billion over the next five years. UDLP estimates that over 50 percent of the Crusader work effort will be performed by the other three team members.

Multiple Launch Rocket System (MLRS) Carriers

MLRS vehicle assembly transferred from San Jose to York. The San Jose facility will retain structure fabrication. The York facility will assemble four MLRS carriers per month, a decrease from the rate of six or seven vehicles per month at San Jose prior to October 1994. UDLP will build 93 MLRS carriers through December 1996: 44 will be for the Army and 49 for FMS.

M1 Breacher

The M1 Breacher is currently in the demonstration and validation phase of system development. UDLP is evaluating two prototypes it completed in February 1995 under an initial $72.7 million contract. The Army will acquire approximately 350 Breachers, beginning in 1997, as part of its $396 million budget for the entire Breacher program. Deliveries will begin in 1999 on the funded requirement for 106 Breachers.

M9 Armored Combat Earthmover (ACE)

UDLP is producing 182 M9 ACEs for the Marine Corps and National Guard, with deliveries on this $78 million contract to occur through September 1996. The Army has no plans to procure additional M9s for its own inventory.

M88 Family of Vehicles

In 1994, UDLP won orders for variations of the M88 FOV from both the U.S. Army and the Kingdom of Kuwait. UDLP began LRIP in September 1994 for 13 U.S. Hercules (M88A1E1) vehicles. In December 1994, UDLP received additional orders for 15 U.S. M88A1s and 14 Kingdom of Kuwait M88A1s, bringing the total value of the awards to over $90 million. The U.S. Army will field the first unit equipped with the Hercules in early 1997, and the Army could award a production contract in mid 1997. Department procurement objectives recommend buying a total of 348 Army and 67 Marine Corps vehicles.

M109A6 Paladin Self-Propelled Artillery Upgrade

The Paladin program is an extensive Army modernization that will upgrade approximately 824 M109A2/A3s to the Paladin (M109A6) configuration. In this program, York welds, machines, and manufactures new turrets and then Chambersburg assembles the turrets onto chassis that have been overhauled at the Letterkenny Army Depot. Letterkenny provides kits that include new and salvaged parts that UDLP will use to attach the turrets to the hulls. The Chambersburg facility then finishes the conversion. Since the initial award in 1993, the Army has exercised options for 20 additional vehicles, bringing the total value to $329 million. The last delivery is scheduled for the third quarter of 1998.

M113A3 Reliability Improved Selected Equipment (RISE)

The M113A3 RISE is an upgrade to 471 M113A2 personnel carriers. The Army awarded UDLP the $23 million contract in September 1993. This was the first time that a commercial firm had been awarded an upgrade contract on the M113 family of vehicles. UDLP began deliveries in November 1994 from the Anniston facility. The last delivery is scheduled for the first quarter of 1996.

M1068 Standardized Integrated Command Post System (SICPS)

The M1068 is a variant of the M577A2, modified to accommodate the next generation of automated command and control systems. UDLP won a contract for 168 M1068 conversion kits in 1994. The Red River Army Depot will use the kits to perform the conversions, beginning in 1995. The Army intends to convert about 2,050 of its M577A2 fleet to the M1068 configuration by 2003; this will make the fleet two-thirds M1068s and one-third M577A2s.

4.2 PUBLIC SECTOR FACILITIES

The useful life of a TCV greatly exceeds the useful life of its components. A new main battle tank, for example, might last thirty years, but will require a new cannon after every twelve years (1,250 round life), new sprockets after two years (1,500 mile life), new tracks after two and a half years (2,000 mile life), complete overhauls every seven and a half years (6,000 mile life), and periodic upgrades as technology improves. The Army plans for 800-850 miles and 100 cannon rounds per year as its peacetime training rates for the tank. The Army utilizes depots and arsenals to maintain TCVs. Depots store, overhaul, and repair the TCV systems, subsystems, and components. Arsenals store, manufacture, and repair specific defense components.

Depots

In the past five years, DoD has reduced the number of TCV depots from ten in 1990 to five today. Personnel strength has decreased 36 percent. The Army operates three depots and the Marine Corps operates two (Table 4-6).

TABLE 4-6
DESCRIPTION OF DEPOT FACILITIES

LOCATION	NUMBER EMPLOYEES	MAINTENANCE SPACE (Sq. Ft.)	PRINCIPAL PRODUCTS
Anniston AD, Anniston, AL	3,215 civilian 8 military	1,500,000	Overhaul/Rebuild of Heavy Combat Vehicles
Letterkenny AD,* Chambersburg, PA	2,135 civilian 12 military	2,500,000	Overhaul/Rebuild of Artillery
Red River AD,* Texarkana, TX	2,619 civilian 11 military	1,300,000	Overhaul/Rebuild of Med/Light Combat Vehicles
MCLB Albany Albany, GA	1,028 civilian 10 military	2,203,765	Overhaul/Repair of all Marine Corps Combat Vehicles
MCLB Barstow Barstow, CA	1,022 civilian 10 military	2,394,899	Overhaul/Repair of all Marine Corps Combat Vehicles
Total	10,019 civilian 51 military	9,898,664	

* Letterkenny Army Depot and Red River Army Depot have been recommended for realignment by the 1995 Defense Base Realignment and Closure (BRAC) Commission. Realignment would not impact ongoing TCV work.

Anniston Army Depot (ANAD), Anniston, Alabama

ANAD is the sole depot capable of overhauling and rebuilding the main battle tanks used by the Army, Marine Corps, and many allied nations. ANAD repairs and overhauls the M1 Abrams, M60 family of vehicles, M551A1, M88A1, M728 CEV, and Armored Vehicle Launcher Bridge. Other ANAD missions include overhaul of subassemblies and fabrication of end items and components not accessible through normal supply sources. ANAD receives, stores, and issues major end items, such as tanks, wheeled tactical vehicles, and small arms.

ANAD has the capability for overhauling Abrams turbine engines, tearing down tracked vehicles, and repairing components. The facility has armor welders, pneumatic system mechanics, artillery repairers, heavy equipment operators, electronic system mechanics, optical instrument repairmen, and ordnance equipment mechanics. The depot is currently working at 87 percent of capacity.

Letterkenny Army Depot, Chambersburg, Pennsylvania

Letterkenny Army Depot specializes in tracked artillery vehicle repair. The current major TCV program is the M109A6 Paladin upgrade. The skills provided in the facility include armor welder, pneumatic system mechanic, artillery repairer, heavy equipment operator, electronic system mechanic, optical instrument repairman, and ordnance equipment mechanic. The depot is currently working at 65 percent of capacity.

Red River Army Depot, Texarkana, Texas

Red River Army Depot is the designated maintenance point for all medium/light combat vehicles, including the Bradley Fighting Vehicle, the M113 family of vehicles, the Multiple Launch Rocket System, the M981 Fire Support Team Vehicle, and the M901A1 Improved TOW Vehicle. Red River is responsible for supplying 7 of 11 active Army divisions based in the central United States, 16 training schools, and numerous reserve units. The depot is currently working at 49 percent of capacity.

The equipment and processes used in the facility are tracked vehicle maintenance, repair, machining, and fabrication. The facility has armor welders, pneumatic system mechanics, artillery repairers, heavy equipment operators, electronic system mechanics, optical instrument repairmen, and ordnance equipment mechanics.

Marine Corps Logistics Base (MCLB) Repair Division, Barstow, California

MCLB Barstow provides West Coast depot level overhaul/repair and modification to all Marine Corps combat vehicles. The Division consists of four facilities that include a central repair facility, calibration lab, optics shop, and x-ray facility. It also provides repair, testing, and calibration of electronic, mechanical, electro-optic, and fiber-optic equipment. The facility has various engine and transmission dynamometers, three dry filter paint booths, an x-ray machine, and a drive-in paint/corrosion removal, plastic media blast facility.

Marine Corps Logistics Base (MCLB) Repair Division, Albany, Georgia

MCLB Albany provides East Coast depot level overhaul/repair and modification of all Marine Corps combat vehicles. The Division consists of 27 buildings on 242 acres of land. It also provides repair, testing, and calibration of electronic, mechanical, electro-optic, and fiber-optic equipment.

Arsenals

The Army maintains two arsenals, Rock Island and Watervliet, which support TCVs. These arsenals are summarized in Table 4-7.

TABLE 4-7 DESCRIPTION OF ARSENAL FACILITIES			
LOCATION	**NUMBER OF EMPLOYEES**	**SIZE**	**PRINCIPAL PRODUCTS**
Rock Island, Rock Island, IL	2,187 civilian 9 military	946 Acres	Gun mounts
Watervliet, Watervliet, NY	1,390 civilian 5 military	142 Acres	Cannon breeches
Total	3,577 civilian 14 military	1,088 Acres	

Rock Island Arsenal

Rock Island Arsenal is located on a 946-acre island in the Mississippi River, between Illinois and Iowa. The arsenal has evolved over the past 100 years into a center of technical excellence for weaponry and support equipment. Completion of a multi-year modernization project -- called a Renovation of Armament Manufacturing (REARM) -- in 1993 has greatly enhanced the arsenal's physical plant, machine tool inventory, and data processing capabilities. Rock Island produces artillery, gun mounts, recoil mechanisms, weapons simulators, and associated spare and repair parts. The arsenal is currently operating at 57 percent of capacity.

Watervliet Arsenal

Watervliet Arsenal, located in upstate New York, was originally established as a result of the War of 1812. In 1883, Congress authorized the establishment of a national gun factory and Watervliet Arsenal was selected to be converted to that purpose. DoD budgeted $300 million during the 1980s for a modernization program that built new facilities, obtained sophisticated manufacturing equipment, and revitalized the workforce's training program. The arsenal is currently operating at 36 percent of capacity.

5.0 ASSESSMENT OF TCV INDUSTRIAL CAPABILITIES

TCV industrial capabilities are and will remain adequate to meet the Department's TCV requirements.[24] Current ongoing (new vehicle, derivative, and upgrade/modification) DoD programs, coupled with prospective foreign sales of medium/light vehicles, generally will be sufficient to sustain needed industrial (engineering and manufacturing) capabilities through 2001. Planned advanced technology demonstrators and funded research and development programs will also sustain a level of TCV engineering capabilities that will be just adequate to support TCV technology needs.

U.S. TCV producers depend heavily on DoD business. TCV prime contractors and suppliers are facing a difficult transition from the peak years of TCV production in the mid-1980s (approximately $6 billion per year) to the $1.1 billion to $1.6 billion annual procurement budgets anticipated for the foreseeable future. However, despite declining sales and excess capacity, the two prime contractors, General Dynamics Land Systems (GDLS) and United Defense, Limited Partnership (UDLP), that manufacture and assemble TCVs have been profitable in recent years. DoD anticipates these firms will have sufficient business to sustain needed industrial capabilities. The component producers who supply prime contractors with parts for new manufacturing -- and in some cases supply DoD directly with parts for repairing and maintaining equipment -- also are expected to meet the Department's known requirements in the coming years. As explained later in this chapter, the Department is already taking steps to assure the availability of a small number of TCV components and recognizes that it might have to spend time and resources to respond to unanticipated problems as they arise in the future.

[24] This assessment of TCV industrial capabilities is based primarily on the spending plans established in the February 1995 Future Years Defense Plan (FYDP), which covers fiscal years 1996 through 2001, and the Defense Planning Guidance. (Unless otherwise noted, all years in this chapter are fiscal years.) This assessment considered spending for years after 2001 only for those programs with well defined plans.

The Department plans to develop a TCV modernization plan that will address the aging TCV fleet, requirements for new and follow-on vehicles, and technology needs. This plan may lead to changes in projected Department requirements, particularly in technology areas.

The Department's TCV procurements have declined considerably as a result of the end of the Cold War. TCV procurement declined from a high of $6.2 billion in 1983 to a low of $0.9 billion in 1994. The Department plans to increase procurement funding for TCV systems from $1.1 billion in 1995 to $1.6 billion in 2001 -- a total expenditure of $9.2 billion (1995 constant dollars) over the period 1995-2001.

TCV research and development funding[25] will decline from $0.7 billion in 1995, to about $0.5 billion in 1999, with an increase to about $0.6 billion planned for 2001 -- a total expenditure of $4.3 billion (1995 constant dollars) over the period from 1995-2001.

5.1 PRIME CONTRACTOR INDUSTRIAL CAPABILITIES

Two prime contractors -- General Dynamics Land Systems (GDLS) and United Defense, Limited Partnership (UDLP) -- design, integrate, manufacture and assemble TCV systems for the DoD. Despite recent reductions in funding for TCV procurement, these two firms have been profitable. In 1994, UDLP earned $95.7 million on sales of $1.08 billion -- a return of 8.8 percent on sales. Also in 1994, GDLS Vehicle Manufacturing earned $72.5 million on sales of $828.9 million -- a return of 8.7 percent on sales.

The prime contractors have reacted to funding reductions by taking significant cost saving steps, including consolidating facilities, reducing personnel, and improving production processes. Both firms are continuing this process. GDLS, for example, has reduced personnel by 79 percent and expects to reduce the number of its facilities from 15 to seven by the end of 1995. UDLP has

[25] Research and development funding includes science and technology activities and weapon system development (heavy, medium/light, and HTI research, development, and test and evaluation (RDT&E) funding). Funding is discussed in greater detail in section 3.0.

reduced personnel by 30 percent and now is consolidating engineering and design work in San Jose, California, component manufacturing in Aiken, South Carolina, and final manufacturing and assembly in York, Pennsylvania.

The prime contractors also are restructuring their business relationships with suppliers. GDLS has reduced the number of its suppliers from 3,000 to about 600, while UDLP has dropped from 1,250 to roughly 250 suppliers. The reduction in suppliers reflects both the recent decline in the procurement of new TCV systems and the prime contractors' efforts to manage suppliers in a lower production volume environment more efficiently. The prime contractors also are developing long-term, strategic partnerships with a reduced number of subcontractors, establishing multi-year contracts for some components, and, in some cases, qualifying new suppliers. In spite of these successes, the rapid reduction in business has created supplier management challenges as suppliers leave the business. The prime contractors and DoD managers monitor some items intensively to ensure that suppliers maintain industrial capabilities and product quality.

Current ongoing DoD programs, coupled with prospective foreign sales of medium/light vehicles, generally will be sufficient to sustain needed industrial capabilities through 2001. In the heavy class, between 1996 and 2001, the Department plans to fund M1A2 and Hercules upgrades, HAB and Breacher derivatives, and the new Crusader development program. In the medium/light vehicle class over the same period, the Department plans to fund Bradley, M113 and Paladin upgrades; C2V and BFIST derivatives; the new AGS program; and the AAAV development program. Crusader and AAAV production is scheduled to begin in 2004 and 2006, respectively.

Retaining skilled engineering and manufacturing personnel is a key to maintaining many critical industrial capabilities. Planned TCV funding should retain key skilled workers, even if the workers must switch to new programs or places of employment. In the aerospace industry, DoD has observed that key personnel have migrated from weapon program to weapon program -- and in some cases from company to company -- as one program goes out of production and another begins. The same situation may begin to apply to the TCV industry.

Both prime contractors are developing the industrial capabilities to design, integrate, and fabricate both heavy and medium/light vehicles. Traditionally, GDLS focused on heavy vehicles, and UDLP focused on medium/light vehicles. GDLS has demonstrated its interest in producing medium/light vehicles by fabricating an aluminum Paladin structure and the aluminum AAAV advanced technology demonstrator. UDLP is currently under contract to produce the heavy class Hercules and Breacher programs. UDLP also is under contract to develop the heavy class Crusader program. GDLS and UDLP are competing for the development and production of the AAAV.

In summary, the two TCV prime contractors are both profitable and capable of meeting DoD requirements, and planned funding levels should keep them that way through 2001. Significantly, both companies have positioned themselves to be more competitive and flexible, and hence better prepared to meet future challenges. The existence of both TCV prime contractors encourages competition and innovation.

5.2 COMPONENT AND SUPPLIER INDUSTRIAL CAPABILITIES

Most suppliers have maintained, and will continue to maintain, the capabilities needed to support DoD's heavy and medium/light TCV requirements. Commercial applications will sustain some capabilities, such as those for communications equipment. Other defense mission area requirements (those for helicopters, fixed-wing aircraft, and naval vessels, for example) will sustain capabilities for fire control; command, control and intelligence; and defense against nuclear, biological, and chemical weapons. DoD requirements and prospective foreign sales generally will sustain those supplier capabilities necessary for TCV-unique components such as gun mounts, gun tubes, drive trains, stabilization and suspension systems, and armor.

The prime contractors and government item managers have adequate suppliers to provide the capabilities needed to support new procurements and to maintain current systems. Most TCV components have multiple suppliers. Table 5-1 lists key TCV components, the number of suppliers, and TACOM projections of production lead times (from a warm production base). In most cases, the production lead times are under a year, and none exceeds a year and a half.

TABLE 5-1 TCV KEY COMPONENT SUMMARY		
Component	Number of Providers	Production Lead Time (PLT) (Days)
Engines, Diesel	3	150
Engines, Turbine	1	540
Transmissions	4	300
Final Drives	2	300
Track	3	180
Road Arms	4	270
Road Wheels	6	240
Sprockets	2	180
Torsion Bars	2	240
Abrams Rotary Shock Absorbers	2	330
Air Filters	2	240
Vehicle Structure	2	360
Depleted Uranium Armor	1	360
Fire Control	Various [1]	420
Turret and Gun Drive	2	420
Gun Mounts	2	300
Cannon	1	360

NOTE
1. Numerous components and subsystems are procured from different suppliers and provided to the prime contractor to incorporate into the fire control system.
Source: U.S. Army TACOM.

Some contractors, General Dynamics Land Systems in particular, have expressed concern about the fragility of the supplier base. GDLS has stated it needs 120 M1A2 upgrades per year to keep its supplier base stabilized and to control costs. As procurements have declined, some TCV suppliers have exited the business. This is a normal business response to reduced demand. Nevertheless, DoD expects that the component producers who supply prime contractors with parts for new manufacturing -- and in some cases supply DoD directly with parts for repairing and maintaining equipment -- will be able to meet the Department's known requirements in the coming years, despite sharp declines in the number of suppliers. The Department is already taking steps to

assure the availability of a small number of TCV components, and recognizes that it might have to spend time and resources to respond to unanticipated problems as they arise in the future.

Examples of instances where the Department has taken action to sustain supplier capabilities include:

AGT 1500 Engine. The Department currently has no known requirements for new AGT 1500 engines. However, DoD plans to field the Abrams tank well into the next century. In May 1995, Allied Signal Engines produced the last new AGT 1500 engine at the Stratford Army Engine Plant which, in accordance with the recommendations of the 1995 Defense Base Closure and Realignment Commission, will close over the course of the next few years if Congress does not reject the Commission's recommendations. Anniston Army Depot will continue to overhaul AGT 1500 engines, as required, to meet future requirements, including those for the Abrams Upgrade Program.

A DoD and Allied Signal transition team is developing a plan to transfer Stratford operations to other Allied Signal locations. Relocation of commercial equipment is scheduled to start in January 1996. All commercial and AGT 1500 operations are to be relocated by December 1996. Congress appropriated $47.5 million to improve AGT 1500 performance and production efficiency in a low production rate environment, and to procure service life extention engines. This funding will also sustain unique manufacturing and technical capabilities. The $47.5 million includes $32.5 million for a service life extension overhaul program, $9 million for an engineering durability program, and $6 million to achieve more efficient production of required spare parts and components. In addition, there are approximately $80 million in spare parts replenishment and build ahead procurements. This build ahead is required for the orderly transition of the industrial capabilities of the AGT 1500 engine to another facility.

X1100 Transmission. The Department does not need to buy more Allison Transmission Division (ATD) X1100-3B transmissions to meet its requirements. Unlike Allied Signal, Allison will be able to maintain its industrial capability through 2001 by upgrading the X1100 transmission

for the M1A2 Abrams tank upgrade program. Allison produces the X1100-3B in ATD Plant 14, a contractor-owned, contractor-operated (COCO) facility with government furnished equipment that can produce 180 transmissions per month. Currently, ATD is producing only 10 upgrade transmissions per month (the equivalent of six new transmissions).

In order to utilize this excess capacity, Allison Transmission has signed a dual use lease agreement with the Government that allows Allison to use the government equipment for commercial products, as long as there is no adverse impact on government requirements. This agreement allows Allison to produce commercial work in ATD Plant 14. The dual use lease is the first of two actions required to retain the X1100-3B core capability at a reduced cost to the taxpayer. This lease, and funding of an idle facility use contract, will avoid increased overhead costs associated with under-used or idle plant equipment. By sharing the overhead costs between numerous customers, the Government benefits by a reduction in the prices for the X1100-3B upgrade transmissions.

V-903 Diesel Engine. Cummins Engine Company has been a commercial producer of diesel engines for over 75 years. The government portion of its business represents less than two percent of its total operation. The Department has new vehicle production and sustainment requirements for the Cummins V903 diesel engine for the BFVS, M9 ACE, USMC AAV7A1, C2V, EFVS, and BFIST that extend well into the next century. However, in recent years these requirements have fallen below a rate required by the contractor to continue to produce this engine. The Army and USMC funded a plan to maintain production at two engines per day through calendar year 1996. The Army will request funds for 1997 to buy out all known remaining V903 engine new vehicle requirements which would be completed in 1999.

Rubberizing Process. Goodyear Tire & Rubber Corporation is the only full service rubberizer remaining in the TCV industry. Goodyear has the capability to provide track for all TCVs. Reductions in the number of end items supported, along with significantly improved inventory management, have substantially reduced the combined TCV track requirements for the Department. Because of the magnitude of reductions (from 517,000 track blocks in 1992 to

200,000 for 1995), Goodyear announced it would consider leaving the defense business if requirements fell below 200,000 track blocks per year. The Army analyzed Goodyear's capacity and industrial capabilities and negotiated a two-year contract for 200,000 track blocks per year, ending in 1996. The Army is also exploring other alternatives to retain necessary rubberizing capabilities after 1996.

In summary, the Department is committed to identifying and addressing supplier concerns as they arise. The Department, however, believes current programs and available resources, coupled with selected actions such as those described above, plus funding stability, will be sufficient. Funding stability, such as can be achieved with multi-year contracting, can be as critical as absolute funding dollars. Over the next decade, the Department will also balance the need to maintain current industrial capabilities for manufacturing TCV systems with the opportunity to take advantage of several new, and potentially revolutionary, technologies. Emerging technologies could offer dramatic advances in materials, armor, guns, drive mechanisms, and many key TCV subsystems and components. Future TCV systems may be substantially different from today's. On the one hand, the Department must avoid unacceptable risks through the loss of current capabilities. On the other, the Department must not spend scarce resources maintaining capabilities not needed to meet current requirements when it would make more sense to field next generation TCV technologies. The Department will manage TCV industrial capabilities carefully to strike the proper balance between maintaining the capabilities of today and fielding the capabilities of tomorrow.

5.3 ENGINEERING CAPABILITIES IN RESEARCH AND DEVELOPMENT AREAS

The Department's planned TCV weapon system development programs and specific TCV functional area science and technology activities[26] will sustain the engineering capabilities

[26] TCV weapon system development programs include specific TCV weapon system RDT&E programs and Horizontal Technology Integration (HTI) programs. TCV mission area science technology activities include technology development activities plus efforts under the Department's Advanced Technology Demonstrator initiatives.

necessary to meet the Department's TCV technology needs. The Department's Crusader and AAAV development programs include science and technology development activities associated with liquid propelled munitions, automated munitions loaders, automated supply feed systems, lightweight propulsions systems, composite hulls, hydropneumatic suspensions, and battlefield digitization. The HTI RDT&E programs address those technologies that the Department applies to a family of systems, rather than to unique systems (such as helicopters, tracked vehicles, wheeled vehicles, etc.). HTI programs include the second generation forward looking infrared sensor, eyesafe laser rangefinder, global positioning system (GPS), and battlefield digitization.

TCV engineering activities in science and technology areas include projects that address the mobility, lethality, and survivability mission areas. Mobility projects focus on propulsion, structures, and drive trains. Lethality projects address activities associated with armaments. Survivability projects concentrate on improving detection, armor penetration, and hit and kill avoidance. While applications are not being explored for all TCV systems, planned projects will sustain a level of engineering capabilities that will be just adequate to support the full range of TCV technology needs.

5.4 SUSTAINMENT CAPABILITIES

DoD's ability to support the daily readiness of fielded TCV weapon systems is at an all time high. Inventory levels for spare and repair parts are approaching 90 percent of their target levels. The rise in inventory is a result of force structure reductions (16 to 10 active duty Army divisions), Operation Desert Storm returns from the field, and a 68 percent decline in sustainment requirements since 1991. These high inventory levels give the Department the ability to support two major regional conflicts.

High inventory levels, although positive from an operations perspective, have reduced revenues for some TCV suppliers. Whereas the Department spent approximately $600 million a year for sustainment spare and repair parts before Operation Desert Storm, it will spend $160

million in 1995. The Department expects the sustainment parts funding levels to rise to a stable level of $232 million in 1998.

The lower funding levels suggest the Department will rely on fewer suppliers because some suppliers will leave the business as a result of the lower volumes. The Department does not expect to lose any specific required industrial capability. However, it does expect that the TCV industry will take several years to size itself to the new funding levels. In the interim, DoD plans to monitor TCV suppliers intensively to ensure they can provide the necessary sustainment capabilities.

TCV sustainment capabilities also include engineering support to fielded TCV weapon systems. Retaining sustaining engineering (systems technical support) expertise appears to be a serious sustainment problem. DoD generally acquires TCV sustaining engineering as part of production efforts and does not budget for it separately. Production levels through the 1980s provided adequate sustaining engineering capabilities. However, as production volumes decline, funds available to meet sustaining engineering requirements also decline, and needed sustaining engineering capabilities could erode. The Army is examining alternatives to provide adequate TCV sustaining engineering capabilities, despite declining procurement. One option under consideration is managing and funding sustaining engineering separately from procurement, as DoD does for some other types of weapon systems.

5.5 SUMMARY

The Department and its prime contractors are effectively managing their resources to ensure TCV industrial capabilities will be available to design, fabricate, and support current and future TCV requirements. Despite a difficult transition period, ongoing and planned programs identified in the Future Year Defense Program (FYDP), coupled with prospective foreign sales of medium/light vehicles, will be adequate to sustain the industrial capabilities to design, integrate, and produce TCVs for known DoD requirements. Current ongoing science and technology activities, advanced technology demonstrators, and weapon systems development programs will sustain a level of engineering capabilities just adequate to support TCV technology needs. TCV prime contractors are taking aggressive steps to remain profitable and competitive in both heavy

and medium/light vehicles. TCV suppliers generally can support demands from heavy and medium/light sector classes. In response to problems in a few product areas, the Department has already taken steps to ensure that adequate capabilities are maintained. As procurement declines, DoD will continue to monitor suppliers for particular end items to ensure they can maintain required industrial capabilities and quality.

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6.0 SUMMARY

- Tracked Combat Vehicles (TCVs) are ground combat systems classified into two classes -- heavy and medium/light -- based on gross vehicle weight.
- TCVs must meet stringent and highly specialized military operational requirements. TCV design, integration, and most key manufacturing capabilities are not available from commercial, or other defense, industries.
- U.S. TCV producers depend heavily on DoD business.
- DoD TCV procurement requirements have declined significantly from the peak production years of the mid-1980s. For example, the U.S. Army does not plan to acquire any new tanks in the next ten years. However, DoD funding is expected to remain relatively stable for the foreseeable future. Funding stability can be as critical as absolute funding dollars.
- The Department plans to develop a TCV modernization plan. The plan will address the aging TCV fleet, requirements for new and follow-on vehicles, and technology needs. This plan may lead to changes in projected Department requirements, particularly in technology areas.
- The world export market for heavy TCVs is limited. Prospects for foreign sales of U.S. heavy TCVs are therefore also limited. The export market for medium/light TCVs is good. Therefore there are better prospects for U.S. foreign sales of medium/light TCVs.
- Despite a difficult transition period, ongoing and planned DoD new vehicle, derivative, and upgrade/modification programs, coupled with prospective foreign sales of medium/light vehicles, generally will be sufficient to sustain needed prime contractor and supplier industrial (engineering and manufacturing) capabilities.
- Planned advanced technology demonstrators and funded research and development will sustain a level of TCV engineering capabilities that will be just adequate to support TCV system technology needs.
- As DoD requirements have declined, the TCV industry has consolidated from three prime contractors to two -- General Dynamics Land Systems and United Defense, Limited Partnership. Both prime contractors are profitable.

- Both prime contractors are taking steps to reduce costs and improve their competitive position by:
  - Consolidating operations and reducing their supplier base, and
  - Developing the ability to design, integrate, and fabricate both heavy and medium/light TCVs.
- The existence of two prime contractors encourages competition and innovation.
- As procurements have declined, some TCV suppliers have exited the business. This is a normal business response to reduced demand.
- Prime contractors and DoD managers are monitoring suppliers as procurements decline to identify areas of concern.
- In a few cases, DoD has taken action to ensure it has continued access to the components it needs to meet requirements. Examples of such actions to sustain supplier capabilities include the Abrams X1100 transmission - Allison Transmission; the AGT 1500 engine - Allied Signal; the V903 engine - Cummins Engine; and the track rubberizing process - Goodyear. The Department will continue to identify and address supplier concerns as they arise. The Department recognizes that it might have to spend time and resources to respond to unanticipated problems.
- Retaining sustaining engineering expertise appears to be a serious sustainment problem. The Army is examining alternatives to provide adequate TCV sustaining engineering capabilities to support fielded systems, despite declining procurement.